FOODNET CANADA
2010 ANNUAL REPORT

PROTECTING CANADIANS FROM ILLNESS

Public Health Agency of Canada
Agence de la santé publique du Canada

Canada

TO PROMOTE AND PROTECT THE HEALTH OF CANADIANS THROUGH LEADERSHIP, PARTNERSHIP, INNOVATION AND ACTION IN PUBLIC HEALTH.

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EXECUTIVE SUMMARY

FoodNet Canada (formerly known as C-EnterNet) is a preventive, multi-partner sentinel site surveillance system, facilitated by the Public Health Agency of Canada, that identifies what food and other sources are causing illness in Canada. FoodNet Canada collects samples at the community level on human illness cases (i.e. exposures and behaviours) and along the farm to fork continuum (i.e. retail food, farm animals, and local water) to identify risks. Information on the areas of greatest risk to human health helps to direct food safety actions and programming as well as public health interventions, and to evaluate their effectiveness. Specifically, its core objectives are to:

- Detect changes in trends in human enteric disease and in levels of pathogen exposure from food, farm animal, and water sources (untreated) in a defined population.
- Strengthen source attribution efforts in Canada by determining significant exposures and risk factors for enteric illness.
- Provide practical preventive information to prioritize risks, compare interventions and direct actions, and to assess the effectiveness of food safety programs and targeted public health interventions.

Each sentinel site is founded on a unique partnership with the local public health unit, private laboratories, and water and agri-food sectors, as well as the provincial and federal institutions responsible for public health, food safety, and water safety. The pilot sentinel site (ON site), comprised of the Region of Waterloo, Ontario, has approximately 525,000 residents, with a mix of urban and rural communities and innovation in public health and water conservation. A second site (BC site) was officially established in the Fraser Health Authority, British Columbia in April of 2010. The BC site includes the communities of Burnaby, Abbotsford, and Chilliwack and has approximately 450,000 residents.

In the ON site, enhanced surveillance of human cases of enteric disease in the community is performed, as well as active surveillance of enteric pathogens in water and food (retail meat and produce) and on farms. In the BC site in 2010, enhanced human disease surveillance began, as did active surveillance of enteric pathogens. However, active surveillance in BC was limited that year to sampling of retail produce (bagged leafy greens).

The following key findings are based on the surveillance data from 2010 in the ON and BCsites:

- In the ON site, a higher number of human endemic cases of enteric disease were reported in 2010 than in 2009, although incidence rates have remained relatively stable over the last five years for most enteric diseases assessed. Exceptions were the rates of verotoxigenic *Escherichia coli* (VTEC) infection and yersiniosis, which have decreased since 2006. (No temporal comparisons could be made for the BC site because that site was not established until April of 2010.)
- Campylobacteriosis remained the most commonly reported endemic disease, with *Campylobacter jejuni* being the only species (in tested samples) associated with human infections in both sentinel sites. *Campylobacter jejuni* was also the most commonly detected species of *Campylobacter* detected on raw chicken breasts purchased at retail in the ON site. Raw chicken had the greatest potential as a vehicle of *Campylobacter* infection

of all tested potential sources, highlighting the importance of safe cooking and food handling practices. Other exposure sources were also important given that *Campylobacter* was also detected in samples of animal feces collected from participating farms in the ON site and that contact with pet dogs was more common for people with campylobacteriosis than for people with other reported diseases in both sentinel sites.

- Salmonellosis was the second most commonly reported endemic disease in both sites. In the retail food surveillance component in the ON site, *Salmonella* was commonly detected in raw chicken and, rarely, in raw beef and pork. The proportion of tested raw chicken samples found to be contaminated has been stable since 2006. *Salmonella* was also detected in fecal samples from broiler chicken, swine, beef, and dairy farms and in untreated surface water in the ON site. Chicken appeared to be a primary reservoir for *Salmonella* causing human illness, as suggested by the similarity of subtypes (e.g. *Salmonella* Enteritidis phage types 8 and 13a) predominating among affected people and retail chicken meat and on chicken farms. Exposure to pet cats was more likely for people with salmonellosis versus other diseases in both sentinel sites in 2010.
- The incidence rate of VTEC infection increased slightly in 2010 in the ON site. This increase is within the normal year to year variation that we would expect. Several of the studied exposure factors were reported more often by cases with VTEC infection than by cases with other enteric illnesses, such as eating at a restaurant. These findings highlight areas for further research to better understand potential exposure for infection. Verotoxigenic *E. coli* was detected in fecal samples collected from beef, dairy, and swine farms in the ON site. Verotoxigenic *E. coli* was also recovered from 12 samples of retail ground beef and from untreated surface water in the ON site. Findings in these sources are well known and expected, and suggest that multiple sources of *E. coli* exist. Cattle remain a major reservoir for *E. coli* O157:H7. Generally, meat products sold in the ON site have had low meat content from the region, due to processors sourcing their meat products from multiple regions of the province and Canada (*1*).
- The incidence rate of yersiniosis, which was primarily attributed to domestic exposure sources, continued to decrease in 2010 in the ON site. Pathogenic *Yersinia enterocolitica* was detected only in fecal samples from swine farms in the ON site.
- One case of listeriosis was reported in the ON site in 2010, and two cases were reported in the BC site. Pathogenic subtypes of *Listeria monocytogenes* were isolated from samples of raw pork, chicken, and beef as well as from bagged leafy greens.
- Both *Giardia* and *Cryptosporidium* were routinely recovered from untreated surface water in the ON site in 2010.
- Reported human cases of shigellosis were mostly travel-related in the ON site, whereas most shigellosis cases in the BC site were domestically acquired in 2010.
- Norovirus and *Giardia* were detected in bagged leafy greens through use of molecular techniques in both sentinel sites in 2010.

- Travel outside Canada continued to add to the burden of enteric disease observed in Canada in 2010, with 31% of the reported cases from the ON site and 24% of cases from the BC site likely involving infections acquired abroad. Safe travel practices continue to be important considerations among Canadians.
- Enhanced, standardized laboratory testing across all FoodNet Canada surveillance components (human, retail, on-farm, and water) has allowed for the identification of patterns in subtype distributions among human cases and potential exposure sources over time. Continued surveillance and addition of more sentinel sites will help in refinement of the key findings and inform prevention and control measures for enteric diseases in Canada.

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1. INTRODUCTION

1.1 Objectives

FoodNet Canada (formerly known as C-EnterNet) is a preventive, multi-partner sentinel site surveillance system, facilitated by the Public Health Agency of Canada, that identifies what food and other sources are causing illness in Canada. FoodNet Canada collects samples at the community level on human illness cases (i.e. exposures and behaviours) and along the farm to fork continuum (i.e. retail food, farm animals, and local water) to identify risks. Information on the areas of greatest risk to human health helps to direct food safety actions and programming as well as public health interventions, and to evaluate their effectiveness. Specifically, its core objectives are to:

- Detect changes in trends in human enteric disease and in levels of pathogen exposure from food, farm animal, and water sources (untreated) in a defined population.
- Strengthen source attribution efforts in Canada by determining significant exposures and risk factors for enteric illness.
- Provide practical preventive information to prioritize risks, compare interventions and direct actions, and to assess the effectiveness of food safety programs and targeted public health interventions.

FoodNet Canada conducts continuous and episodic surveillance activities in four components: human, retail (meat and produce), on-farm (food animals), and water. For a complete list of the pathogen tests performed, see Appendix A. Continuous surveillance occurs throughout the year to identify trends in human disease occurrence, exposure sources, and source attribution for 11 enteric pathogens. Episodic surveillance activities are limited in duration and provide specific information to complement the continuous activities. Detailed descriptions of the FoodNet Canada study design and laboratory methods are available online (www.phac-aspc.gc.ca/FoodNet Canada/niedsp10-pnisme10/index-eng.php).

The 2010 report begins with a summary of the reported human cases of infectious enteric disease in two sentinel sites (one in Ontario and the other in British Columbia), summarizing the outbreak- and travel-related cases separately from the endemic cases (Chapter 2). Chapters 3 through 10 provide information on human cases and exposure sources for 2010 by pathogen. Chapter 11 provides a discussion of the temporal variations observed in the incidence of reported human cases of enteric disease and in the potential exposure sources from June 2005, when FoodNet Canada surveillance activities began in the ON site, to the end of 2010. A summary of FoodNet Canada's ongoing efforts to test and refine methodologies to estimate source attribution are presented in Chapter 12.

The surveillance data provided in this report pertain to two sentinel sites only. Therefore, readers need to be aware that the accuracy of generalizing these results beyond these communities decreases with increasing distance from the specific geographical area. As additional sentinel sites are established, comprehensive information from laboratory and epidemiological analyses from all sites will provide more representative national trends in enteric disease incidence and exposure sources, ultimately providing more accurate source attribution estimates for all of Canada.

1.2 Surveillance Strategy

Human surveillance

The enhanced human disease surveillance component of FoodNet Canada has been fully implemented in two sentinel sites: the Region of Waterloo, Ontario (ON site) and the Fraser Health Authority, British Columbia (BC site).

Each sentinel site is based on a unique partnership with the local public health unit, private laboratories, and water and agri-food sectors as well as the provincial and federal institutions responsible for public health, food safety, and water safety. The ON site, which was established as the pilot sentinel site (June 2005), has approximately 525,000 residents, with a mix of urban and rural communities and innovation in public health and water conservation. A second site (BC site) was officially established in April 2010 in the Fraser Health Authority, British Columbia. The BC site includes the communities of Burnaby, Abbotsford, and Chilliwack and has approximately 450,000 residents.

In the ON site, enhanced surveillance of human cases of enteric disease in the community is routinely performed as well as active surveillance of enteric pathogens in untreated water, in food, and on farms. In the BC site in April 2010, enhanced human disease surveillance began, as did active surveillance of enteric pathogens. However, active surveillance in BC was limited that year to retail sampling of bagged leafy greens, which began in April. For this reason, results presented herein on exposure sources for human cases are restricted to those for the ON site only. Reports for subsequent surveillance years will include exposure sources for human cases in the BC site as well. Furthermore, because only partial year data were available for the BC site in 2010, the seasonal distribution of enteric disease cases was not evaluated for this report but will be explored in future reports.

Retail surveillance

The retail stage of food production represents a point at which consumers can be exposed to enteric pathogens through contaminated food. Since mid-2005, FoodNet Canada has been systematically collecting on a weekly basis samples of fresh raw pork (pork chops), chicken (skin-on chicken breasts until the end of 2007; skinless chicken breasts from 2008 onwards), and beef (ground beef) from 88 randomly selected grocery stores within the ON site. All samples underwent bacterial culture for *Campylobacter*, *Salmonella*, VTEC, and *Listeria*. Additionally, pork samples were tested for *Yersinia* contamination.

In the BC site, retail food sample collection began in April 2010 and was limited to bagged leafy greens at 36 randomly selected grocery stores, with testing for parasites, viruses, and *Listeria monocytogenes*. Similarly, testing of bagged leafy greens has been occurring in the ON site since 2009, although bacterial testing was discontinued in mid-2010 and testing only for parasites, viruses and *Listeria monocytogenes* has continued. Although both domestic and imported bagged leafy greens are tested, the majority are imported.

On-farm surveillance

The presence of enteric pathogens on farms is a potential source of environmental exposure for humans. To estimate the pathogen burden on farms, samples of feces were collected from swine, dairy, beef, and broiler chicken farms in the ON site. Approximately 30 of each type of farm were visited each year. A short management survey, one stored fecal sample (i.e. from a manure pit), and three fresh, pooled fecal samples were obtained at each farm visit. All samples underwent bacterial culture for *Campylobacter, E. coli* O157:H7, *Listeria,* and *Salmonella,* and swine feces also underwent culture for *Yersinia.*

Water surveillance

Another environmental source of pathogen exposure is water. Since 2005, regular, bi-weekly collection of surface water samples has occurred at five points along the Grand River (located in the ON site) to determine the potential for human exposure to pathogens through this source of untreated surface water. The collected samples underwent microbial culture for detection of *Cryptosporidium, Giardia, Campylobacter, E. coli, Salmonella,* and *Yersinia.*

1.3 Definitions

Exposure factor: Possible demographic factor or exposure source in the transmission of infection, such as consumption of contaminated food or exposure to an animal.

Exposure source: Point along the waterborne, food-borne, animal-to-person, or person-to-person transmission route at which people were suspected to have been exposed to a given pathogen.

Outbreak-related case of disease: One of a number of affected individuals associated with a sudden increased occurrence of the same infectious disease, whose illness is confirmed through a public health partner (ON and BC sites) on the basis of laboratory or epidemiological evidence.

International travel-related case of disease: Affected individual who travelled outside of Canada prior to onset of illness, and the expected disease incubation period (varies depending on the pathogen) overlapped with the travel time.

Endemic case of disease: Affected individual who had an infection that was considered sporadic and domestically acquired (i.e. within Canada).

Significant: The term "significant" in this report has been reserved for statistically significant findings (i.e. $p < 0.05$) or, for exposure comparisons between one disease group and another (case-case analysis), a 5% difference between groups.

Verotoxigenic Escherichia coli (VTEC): *Escherichia coli* are normal intestinal inhabitants in humans and animals, and most strains do not cause enteric disease. However, the group of verotoxigenic *E. coli* includes certain toxin-producing strains that can cause severe diarrhea and, in some people (particularly young children), hemolytic uremic syndrome.

1.4 Source Attribution

In each of the following chapters, potential exposures (e.g. swimming, contact with animals, or attending a social event) among cases of enteric disease are reported when the proportion of cases with a given exposure was at least 20% greater than the proportion of cases of all other diseases combined with the same exposure in 2010. This approach, referred to as case-case analysis, was chosen rather than a formal statistical analysis because of the low case numbers for many diseases. For the same reason, no attempt was made to stratify exposure information by patient age or gender. The exposures reported herein therefore represent overall exposures for the general population in each site and are not valid for age- or gender-specific subgroups. No differences were highlighted if there were less than ten cases with exposure data.

The case-case approach is one approach to developing hypotheses for identifying potential exposure factors. Higher proportional differences between cases and other cases combined do not necessarily represent higher risk, but highlight areas where further research may help us to better understand disease sources at the community level.

At least two advantages exist for comparing exposures between cases of one disease and all other cases of disease in an epidemiological investigation. First, the potential for information bias from differential recall between groups is minimized. Second, the use of an ill comparison group removes the need to enrol non-ill persons as controls (*2*), which is generally more difficult than enrolment of diseased individuals.

The association between temporal trends in human cases of enteric disease and in pathogen detection among potential infection sources (considering the possible influence of weather conditions on both) is of interest for source attribution. To be able to assess such associations would require several years of surveillance data. FoodNet Canada is in the process of developing a time-series approach to address the following three main objectives:

- Characterize temporal patterns in human cases and infection sources.
- Assess the potential associations between sources of infection and the disease cases in a global model that would encompass all of the sources together.
- Separately assess the impact of weather conditions on the incidence of human illness and on potential sources of infection to better explain the dynamic of human enteric disease.

Seasonality was not evaluated for the BC site because only partial year data were available but will be explored in future reports.

1.5 Changes to Methodologies for 2010

The year 2010 marks the beginning of FoodNet Canada expansion, with data collection in two sentinel sites within Canada. The expansion involved considerable collaboration with partners in both health authorities (Region of Waterloo Public Health, Ontario and Fraser Health Authority, British Columbia).

Sample collection

In April 2010, collection of bagged leafy greens was initiated in the BC site to match existing sample collection activities in the ON site.

Laboratory testing and methodology

In the on-farm surveillance component in July 2010, *Yersinia* testing was initiated on dairy, beef, and poultry operations.

In the retail component, the method for isolating verotoxigenic *Escherichia coli* (VTEC) from samples of retail ground beef was modified to increase test sensitivity, which resulted in a significant increase in the apparent prevalence of VTEC among ground beef samples. In June 2009, the method for recovering *Yersinia* from samples of retail pork was modified to increase test sensitivity, which resulted in a significant increase in the apparent prevalence of *Yersinia* among pork samples (3% in 2008 to 30% in 2009 and 82% in 2010). However, by July 2010, testing for *Yersinia* in retail pork samples was discontinued given that less than 1% of recovered isolates were pathogenic to humans.

The proportion of Grand River surface water samples from which *Yersinia* was recovered was also considerably influenced by laboratory protocol changes. The changes started in 2008, when a different service laboratory was used. The culture method was then modified in 2009 to enhance its sensitivity, and a molecular pre-screening method was initiated that further increased culture sensitivity. However, in July of 2010, *Yersinia* testing was discontinued, largely because improvements to the method considerably increased the laboratory costs of *Yersinia* isolation from water samples yet a human-pathogenic strain had not been identified in five years of surveillance.

Halfway through 2010, a new method was put into place to detect all strains of VTEC in untreated surface water samples. This method was performed in parallel with the traditional *E. coli* O157:H7 testing of water samples.

2. HUMAN CASE SUMMARY

2.1 Overview of Human Cases of Disease

In 2010, 432 human cases of 11 bacterial, viral, and parasitic diseases were reported to the local public health authorities within the ON site and 303 human cases of 9 bacterial, viral, and parasitic diseases were reported within the BC site (Table 2.1). In the ON site, cases were reported throughout the year, whereas in the BC site, cases were reported from April through December 2010. The three most commonly reported diseases (salmonellosis, campylobacteriosis, and giardiasis) accounted for 81% of the cases in the ON site (Figure 2.1) and 83% of the cases in the BC site (Figure 2.2).

Information on potential exposures to seven pathogens was obtained from 85% (244/288) and 84% (183/217) of the reported cases within the ON and BC sites, respectively, in 2010. Public health inspectors or environmental health officers administered a standardized questionnaire to the affected individuals (or proxy respondents). Preliminary analyses of this information were used to determine the circumstances of the case (e.g. international travel vs. endemic) and compare exposures (Appendix B).

TABLE 2.1. Number of laboratory-confirmed enteric disease cases in the ON and BC sites in 2010.

DISEASE	INCUBATION PERIOD	NO. OF CASES				INCIDENCE RATE	
		Outbreak	Travel	Endemic	Total	Endemic	Total
ON site							
Amoebiasis	2-4 weeks	0	14	12	**26**	2.28	**4.93**
Campylobacteriosis	1-10 days	0	32	112	**144**	21.25	**27.32**
Cryptosporidiosis	1-12 days	0	10	13	**23**	2.47	**4.36**
Cyclosporiasis	2-14 days	0	1	0	**1**	0.00	**0.19**
Giardiasis	3-25 days	0	28	50	**78**	9.49	**14.80**
Hepatitis A infection	15-50 days	0	2	2	**4**	0.38	**0.76**
Listeriosis	3-70 days	0	0	1	**1**	0.19	**0.19**
Salmonellosis	6-73 hours	8	39	82	**129**	15.56	**24.48**
Shigellosis	1-3 days	0	5	1	**6**	0.19	**1.14**
VTEC infection	2-10 days	0	0	12	**12**	2.28	**2.28**
Yersiniosis	3-7 days	0	1	7	**8**	1.33	**1.52**
Total		**8**	**132**	**292**	**432**		

DISEASE	INCUBATION PERIOD	NO. OF CASES				INCIDENCE RATE	
		Outbreak	Travel	Endemic	Total	Endemic	Total
BC site							
Amoebiasis	2-4 weeks	NA	NA	NA	**NA**	NA	**NA**
Campylobacteriosis	1-10 days	0	23	89	**112**	26.22	**32.99**
Cryptosporidiosis	1-12 days	0	3	2	**5**	0.59	**1.47**
Cyclosporiasis	2-14 days	0	3	0	**3**	0.00	**0.88**
Giardiasis	3-25 days	0	8	37	**45**	10.90	**13.26**
Hepatitis A infection	15-50 days	NA	NA	NA	**NA**	NA	**NA**
Listeriosis	3-70 days	0	0	2	**2**	0.59	**0.59**
Salmonellosis	6-73 hours	8	32	56	**96**	16.50	**28.28**
Shigellosis	1-3 days	0	2	4	**6**	1.18	**1.77**
VTEC infection	2-10 days	0	1	9	**10**	2.65	**2.95**
Yersiniosis	3-7 days	0	0	24	**24**	7.07	**7.07**
Total		**8**	**72**	**223**	**303**		

'TRAVEL' = International travel (i.e. travel outside of Canada)

NA = Not applicable; cases of this disease were not reported to FoodNet Canada.

VTEC = Verotoxigenic *Escherichia coli*.

FIGURE 2.1. Relative proportions of human cases of 11 enteric diseases reported in the ON site in 2010.

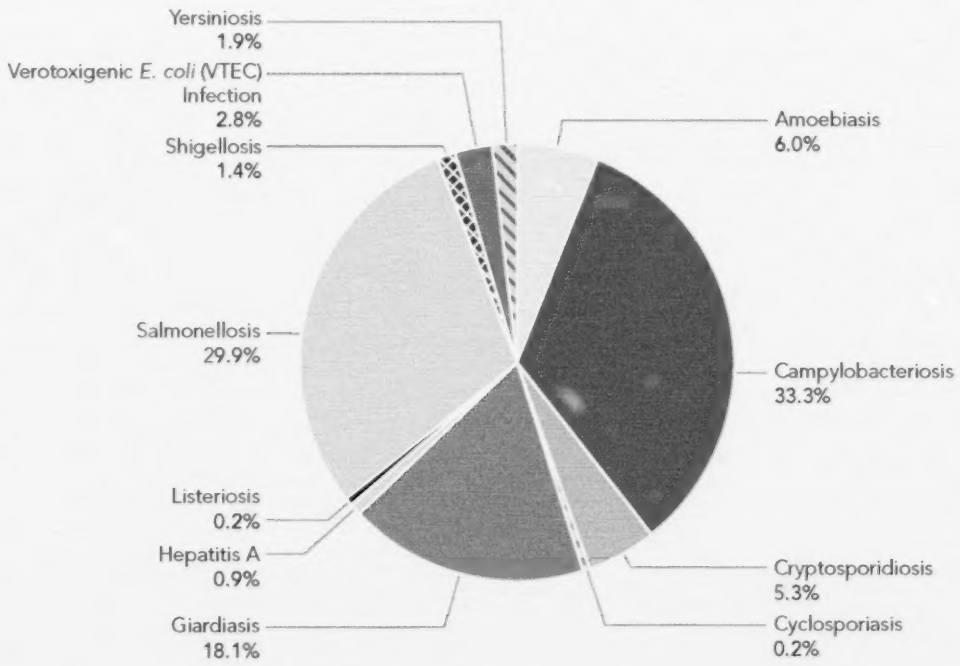
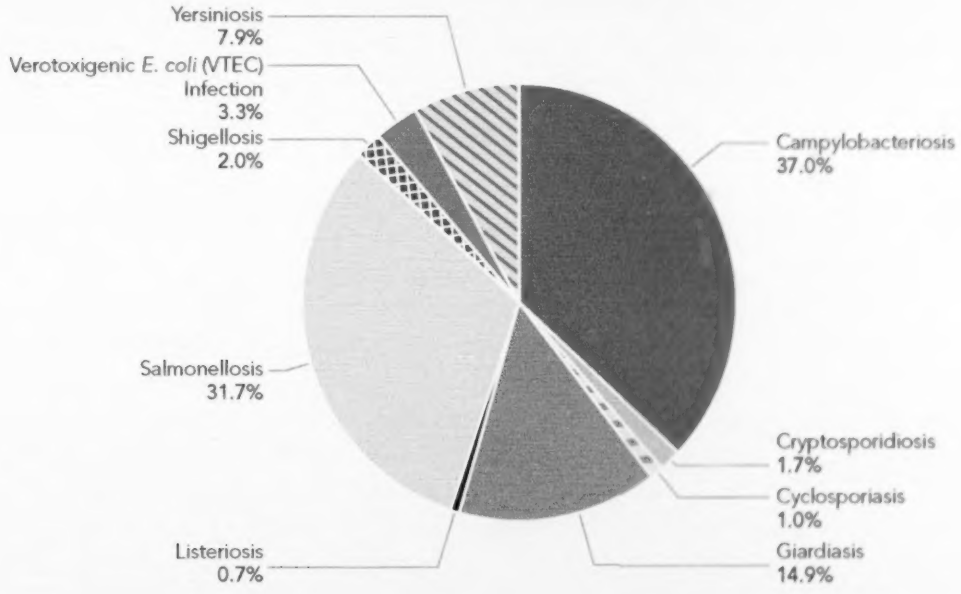


FIGURE 2.2. Relative proportions of human cases of 9 enteric disease cases reported in the BC site in 2010.



Isolation of an organism from specimens that originated from body systems other than gastrointestinal (i.e. specimens other than feces) may reflect more severe illness and an increase in the likelihood of an affected individual seeking medical treatment and diagnostic testing. Among human cases of salmonellosis in the ON site, five involved isolation of the organism from blood. The serotypes of the five associated isolates were Enteritidis (two cases) and Typhimurium, Typhi, and ssp. I 4,[5],12:b:- (one case each). In the BC site, two cases involved isolation of *Salmonella* from blood, and the serovar of both isolates was Enteritidis.

In comparison, *Salmonella* accounted for most of the pathogens reported to the National Enteric Surveillance Program that were isolated from specimens other than feces in 2010. Among those pathogens, *S.* Paratyphi A and *S.* Typhi were the most common (34% and 31% of isolates, respectively). *Salmonella* serovars Enteritidis, Typhimurium, and ssp. I 4,[5],12: b:- constituted less than 5% of isolates collected from non-fecal specimens (*3*).

TABLE 2.2. Number of cases of laboratory-confirmed enteric diseases in the ON and BC sites in 2010, by type of specimen submitted.

DISEASE	ON SITE					BC SITE				
	Blood	Feces	Urine	Unknown	Total	Blood	Feces	Urine	Unknown	Total
Amoebiasis	0	26	0	0	**26**	NA	NA	NA	NA	**NA**
Campylobacteriosis	0	143	0	1	**144**	0	112	0	0	**112**
Cryptosporidiosis	0	23	0	0	**23**	0	5	0	0	**5**
Cyclosporiasis	0	1	0	0	**1**	0	3	0	0	**3**
Giardiasis	0	78	0	0	**78**	0	45	0	0	**45**
Hepatitis A infection	4	0	0	0	**4**	NA	NA	NA	NA	**NA**
Listeriosis	0	1	0	0	**1**	1	0	0	1	**2**
Salmonellosis	5	119	3	2	**129**	2	92	2	0	**96**
Shigellosis	0	6	0	0	**6**	0	6	0	0	**6**
VTEC infection	1	11	0	0	**12**	0	10	0	0	**10**
Yersiniosis	0	8	0	0	**8**	0	24	0	0	**24**
Total	**10**	**416**	**3**	**3**	**432**	**3**	**297**	**2**	**1**	**303**

NA = Not applicable; cases of this disease were not reported to FoodNet Canada.
VTEC = Verotoxigenic *Escherichia coli*.

2.2 Outbreak-Related Cases

In 2010, eight outbreak-associated cases were reported in the ON site, none of which were linked to a nation-wide outbreak.

In the BC site, eight outbreak-associated cases were reported between April and December 2010, two of which were attributed to *Salmonella* Chester infection and linked to a nation-wide outbreak associated with the consumption of headcheese. This outbreak of *S.* Chester occurred between June and August 2010 and resulted in a total of 33 cases reported in multiple provinces including British Columbia, Ontario, Alberta, and Saskatchewan (*3*). The remaining six outbreak-related cases were attributed to local exposure sources.

2.3 Travel-Related Cases

In the ON site, 31% (132/432) of reported cases of enteric disease were classified as associated with international travel (Table 2.1). Salmonellosis, giardiasis, and campylobacteriosis continued to be the three most common diseases, contributing to 75% (99/132) of the travel-related cases. Most of the affected individuals had visited Mexico and the Caribbean region or Asia prior to becoming ill (Table 2.3), which may simply reflect travel preferences of the sentinel site population. As observed in previous years, over half (72%; 28/39) of the people with reported travel-related salmonellosis in 2010 had been to Mexico and the Caribbean region. Giardiasis was the most common disease in people who had travelled to Africa (48%; 11/23). There were no travel-associated cases of verotoxigenic *Escherichia coli* infection reported in 2010.

In the BC site, 24% (72/303) of reported cases were classified as international travel-related (Table 2.1). Salmonellosis and campylobacteriosis were the two most common diseases reported, contributing to 76% (55/72) of the travel-related cases. As was observed in the ON site, most of the affected individuals had visited Mexico and the Caribbean region or Asia prior to acquiring their illness (Table 2.3). One travel-associated VTEC infection was reported in 2010. Readers should note that these data for the BC site do not reflect a full year of data collection.

TABLE 2.3. Number of travel-related cases of enteric disease in the ON and BC sites in 2010, by destination.

DISEASE	AFRICA	MEXICO & CARIBBEAN	ASIA	EUROPE	USA	MULTIPLE OR OTHER DESTINATIONS	TOTAL
ON site							
Amoebiasis	5	2	6	0	1	0	**14**
Campylobacteriosis	2	14	10	4	0	2	**32**
Cryptosporidiosis	2	4	2	0	1	1	**10**
Cyclosporiasis	0	1	0	0	0	0	**1**
Giardiasis	11	7	8	0	1	1	**28**
Hepatitis A infection	0	1	1	0	0	0	**2**
Listeriosis	0	0	0	0	0	0	**0**
Salmonellosis	2	28	5	1	2	1	**39**
Shigellosis	1	0	2	1	0	1	**5**
VTEC infection	0	0	0	0	0	0	**0**
Yersiniosis	0	1	0	0	0	0	**1**
Total	**23**	**58**	**34**	**6**	**5**	**6**	**132**
BC site							
Amoebiasis	NA	NA	NA	NA	NA	NA	**NA**
Campylobacteriosis	0	4	4	5	5	5	**23**
Cryptosporidiosis	0	1	1	0	0	1	**3**
Cyclosporiasis	0	2	1	0	0	0	**3**
Giardiasis	1	2	4	0	0	1	**8**
Hepatitis A infection	NA	NA	NA	NA	NA	NA	**NA**
Listeriosis	0	0	0	0	0	0	**0**
Salmonellosis	1	17	6	1	1	6	**32**
Shigellosis	0	0	2	0	0	0	**2**
VTEC infection	0	1	0	0	0	0	**1**
Yersiniosis	0	0	0	0	0	0	**0**
Total	**2**	**27**	**18**	**6**	**6**	**13**	**72**

NA = Not applicable; cases of this disease were not reported to FoodNet Canada.

VTEC = Verotoxigenic *Escherichia coli*.

2.4 Endemic Cases

The findings presented in the remainder of this report largely refer to endemic cases of human enteric disease. Whereas outbreak-related cases of enteric disease are also attributed to local sources of exposure, they are considered to be unusual events. Through exclusion of cases attributed to outbreaks and international travel, more stable estimates of disease incidence can be provided, and the influence of unusual events on source attribution estimates can be minimized. Reported national and provincial annual incidence rates for each disease include both endemic and travel cases reported nationally for 2010.

3. *CAMPYLOBACTER*

3.1 Human Cases

In the ON site in 2010, a total of 144 cases of human *Campylobacter* infection were reported, representing an incidence rate of 27.3 cases/100,000 person-years. Of these cases, 22% (32/144) were travel-related (6.1 cases/100,000 person-years) and 78% (112/144) were classified as endemic (21.3 cases/100,000 person-years).

In the BC site between April and December 2010, 112 (33.0 cases/100,000 person-years) cases of *Campylobacter* infection were reported. Of these cases, 21% (23/112) were travel-related (6.8 /100,000 person-years) and 79% (89/112) were classified as endemic (26.2 cases/100,000 person-years).

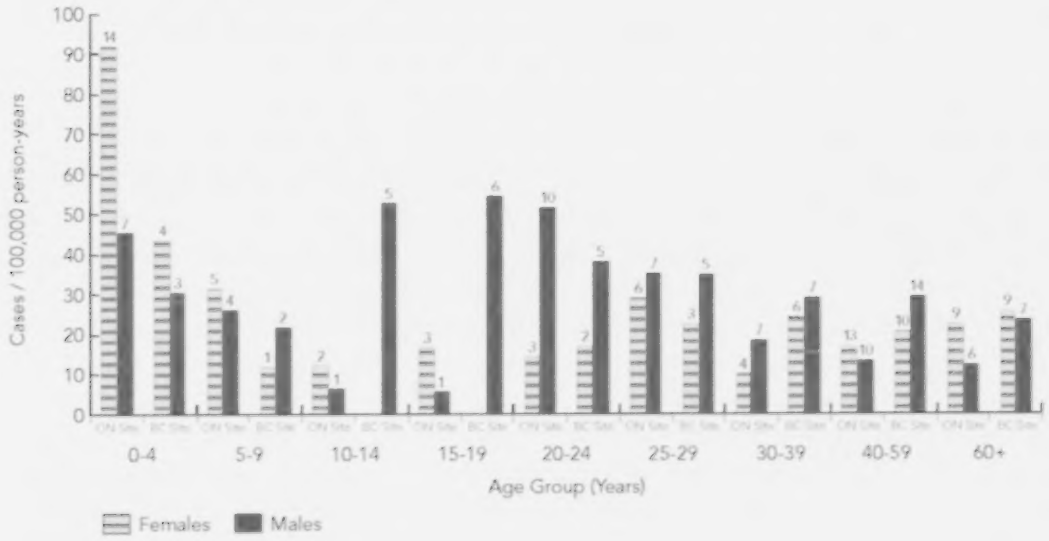
In comparison, the annual incidence rates for campylobacteriosis in 2010 for all of Canada, Ontario, and British Columbia were 26.3, 25.2, and 34.2 cases/100,000 person-years, respectively (**4**).

In the ON site, 59 (22.5 cases/100,000 person-years) endemic cases of campylobacteriosis were in females and 53 (20.1 cases/100,000 person-years) were in males. Incidence rates were highest in females less than five years of age (92.1 cases/100,000 person-years) and males less than five years of age (45.3 cases/100,000 person-years; Figure 3.1).

In the BC site, 35 (20.5 cases/100,000 person-years) endemic cases of campylobacteriosis were in females and 54 (32.0 cases/100,000 person-years) were in males. Incidence rates were highest in females less than five years of age (43.4 cases/100,000 person-years) and males between the ages of 10 to 19 years (53.6 cases/100,000 person-years; Figure 3.1).

All *Campylobacter* isolates recovered from endemic campylobacteriosis cases in the ON and BC sites and subsequently subtyped were identified as *C. jejuni* (Table 3.1).

FIGURE 3.1. Incidence rates of human endemic campylobacteriosis in the ON and BC sites in 2010, by gender and age group.



NOTE: The number of cases is indicated above each bar.

3.2 Case Exposures

In the ON site, 84% (94/112) of the endemic cases of campylobacteriosis had potential exposure information for the 10 days prior to onset of illness (Appendix B.1). In the BC site, 92% (82/89) of campylobacteriosis cases had potential exposure information for the 10 days prior to onset of illness (Appendix B.2).

In the ON site, a higher proportion of campylobacteriosis cases than among people with other reported enteric diseases had a history of contact with household dogs (54%). Contact with pets, including contact with pet food and pet treats, can present an opportunity for infection. Ensuring that proper hand-washing procedures are followed after coming in contact with pets, pet food, and pet treats, will help to reduce the risk of transmission.

3.3 Surveillance of Potential Sources

Food

As in previous surveillance years, a low prevalence of *Campylobacter* contamination was detected in samples of raw retail pork and beef. Prevalence estimates were higher for retail chicken samples, as was also found in previous years. The amount of *Campylobacter* organisms in samples from which they were recovered was low, given that results for 75% of positive samples were below the assay detection limit (i.e. less than 0.3 most probable number of organisms [MPN]/g of sample; Appendix C).

Farm animals

Campylobacter coli continued to be the most common species of *Campylobacter* detected in fecal samples on swine farms in 2010. On the other hand, *C. jejuni* was the most common species on dairy and beef cattle farms. *Campylobacter* was not commonly detected on broiler chicken farms (5% of fecal samples were positive), and this might have been attributable to the dry nature of poultry feces, which can inhibit the survivability of *Campylobacter* (5). Currently, FoodNet Canada is exploring the use of various sample transport media to enhance *Campylobacter* survivability in fecal samples, with the aim of improving culture sensitivity.

Water

Surveillance data suggest that the prevalence of *Campylobacter* in untreated surface water has remained consistent from year to year in the ON site. In 2010, more than half of the *Campylobacter* isolates recovered from water samples were identified as *C. jejuni*. It is interesting to note that not one sample collected downstream of the wastewater effluent (Site E) of the Grand River Watershed in Ontario has tested positive for *Campylobacter* in five years of monitoring.

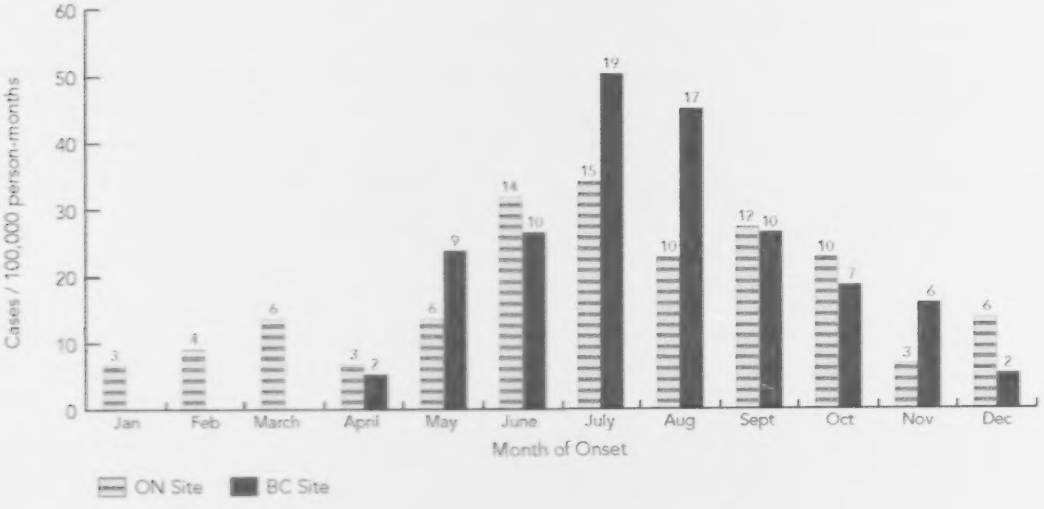
3.4 Temporal Distribution

The seasonal pattern of campylobacteriosis has been well documented in many countries, as has the association of campylobacteriosis with weather conditions. However, temporal trends in potential sources of contamination or exposure have been less studied and their association with human disease trends is usually investigated one source at a time.

In the ON site in 2010, the incidence rates of endemic cases of human campylobacteriosis were significantly higher during the summer months (June, July, and August) than in the spring (March, April, and May) or winter (December, January, and February; Figure 3.2). The incidence rates of campylobacteriosis were also significantly higher in the fall (September, October, and November) than in the winter.

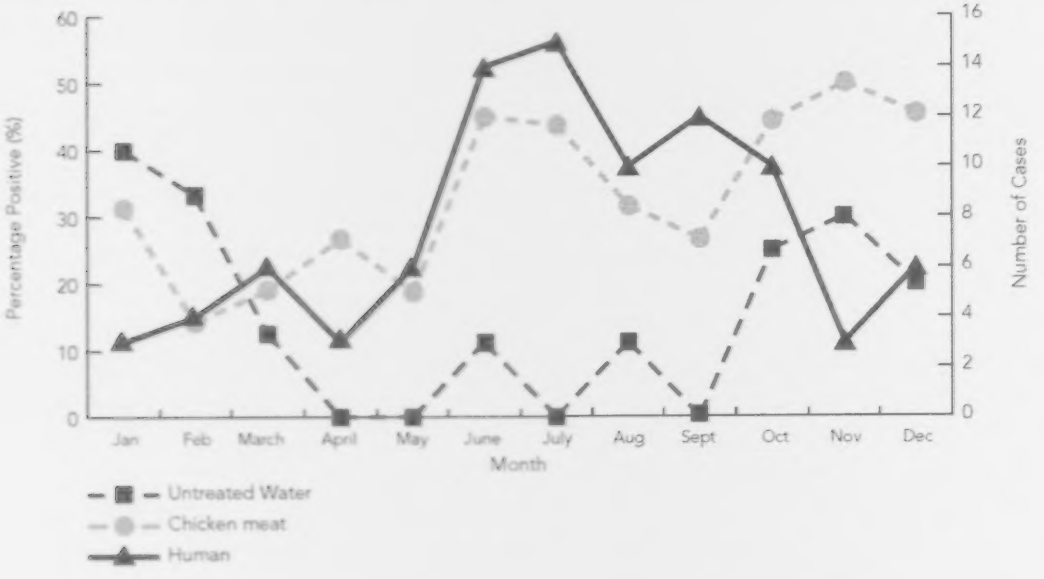
The prevalence of *Campylobacter* contamination of retail meat samples peaked in the summer and fall of 2010 (Figure 3.3). In comparison, *Campylobacter* was more likely to be recovered from surface water samples during the winter months than during other seasons.

FIGURE 3.2. Distribution of reported human endemic cases of campylobacteriosis in the ON and BC sites in 2010, by month.



NOTE: The number of cases is included above each bar.

FIGURE 3.3. Prevalence of *Campylobacter jejuni* contamination among all samples collected on a continuous basis in the ON site in 2010, by month.



3.5 Subtype Comparison

TABLE 3.1. Number (%) of *Campylobacter* isolates detected and subtyped through integrated surveillance activities in the ON site in 2010, with human case information for the BC site provided for comparison.

METHOD	HUMAN		RETAIL			ON-FARM[a]				WATER[b]
	Endemic cases ON site	Endemic cases BC site	Pork chops	Chicken breasts	Ground beef	Swine	Broiler chickens	Beef cattle	Dairy cattle	
Detection										
No. of samples tested	Unknown	Unknown	197	197	197	120	120	119	120	93
No. of isolates recovered	112	89	3 (2%)	70 (36%)	1 (1%)	100 (83%) from 29 farms	7 (6%) from 2 farms	93 (78%) from 30 farms	89 (74%) from 30 farms	22 (24%)
Subtyping										
No. of isolates subtyped	110	39	3	70	1	100	7	93	89	22
Campylobacter coli	0 (0%)	0 (0%)	2 (67%)	5 (7%)	1 (100%)	96 (96%)	0 (0%)	28 (30%)	11 (12%)	5 (23%) from sites A,B,C,D
Campylobacter jejuni	110 (100%)	39 (100%)	1 (33%)	65 (93%)	0 (0%)	0 (0%)	7 (100%)	63 (68%)	61 (69%)	13 (59%) from sites A,B,C,D
Campylobacter lari	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (18%) from sites A,C
Other species	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (4%)	0 (0%)	2 (2%)	17 (19%)	0 (0%)

[a] Fecal samples were collected from 30 farms in the ON site for each type of food animal.

[b] Samples of untreated surface water were collected from five sites along the Grand River in the ON site: Canagagigue Creek (A), Conestogo River (B), Upper Grand River (C), Grand River, near drinking water intake (D), and Grand River, near a wastewater treatment plant effluent point (E).

3.6 Summary of *Campylobacter* Results

What is the same in 2010 as in previous years?

- Campylobacteriosis was the most commonly reported enteric disease in both sentinel sites.
- *Campylobacter jejuni* is the most common species associated with human campylobacteriosis.
- A high proportion of raw chicken samples was contaminated with *Campylobacter*. Pork and beef are rarely contaminated with *Campylobacter*.
- *Campylobacter coli* was detected in fecal samples collected from swine, beef, and dairy farms but not from broiler chicken farms. Six percent of the samples obtained from broiler chicken farms were positive for *C. jejuni* in 2010.
- *Campylobacter jejuni*, *C. coli*, and *C. lari* were detected in untreated surface water; *C. jejuni* remained the predominant species.

What is new?

- Contact with household dogs was more commonly reported in the ON site compared to other cases of reported enteric diseases.
- Comparative genomic fingerprinting is a new molecular method effective for subtyping *Campylobacter*. This method is being used to further subtype all *Campylobacter* isolates collected retrospectively and prospectively by FoodNet Canada to determine clusters common to different sources (*6*). Data and interpretation of the findings will be included in future reports.

What impact do these findings have on public health?

- Enhanced, standardized exposure information for cases of campylobacteriosis in the BC site will be used to inform provincial public health investigations concerning the higher incidence of infection in British Columbia than in the rest of the country and to guide future research and hypothesis generation.

4. *SALMONELLA*

4.1 Human Cases

In the ON site in 2010, a total of 129 cases of salmonellosis were reported, representing an incidence rate of 24.5 cases/100,000 person-years. Of these cases, 30% (39/129) were travel-related (7.4 cases/100,000 person-years), 6% (8/129) were outbreak-related (1.5 cases/100,000 person-years), and 64% (82/129) were classified as endemic (15.6 cases/100,000 person-years).

Human cases of salmonellosis in the BC site were reported from April through December, 2010. During that period, 96 cases of salmonellosis were reported, representing an incidence rate of 28.3 cases/100,000 person-years. Of these cases, 33% (32/96) were travel-related (9.4 cases/100,000 person-years), 8% (8/96) were outbreak-related (2.4 cases/100,000 person-years), and 58% (56/96) were classified as endemic (16.5 cases/100,000 person-years).

In comparison, the annual incidence rates for salmonellosis in 2010 for all of Canada, Ontario, and British Columbia specifically were 20.4, 20.9, and 23.1 cases/100,000 person-years, respectively (**4**).

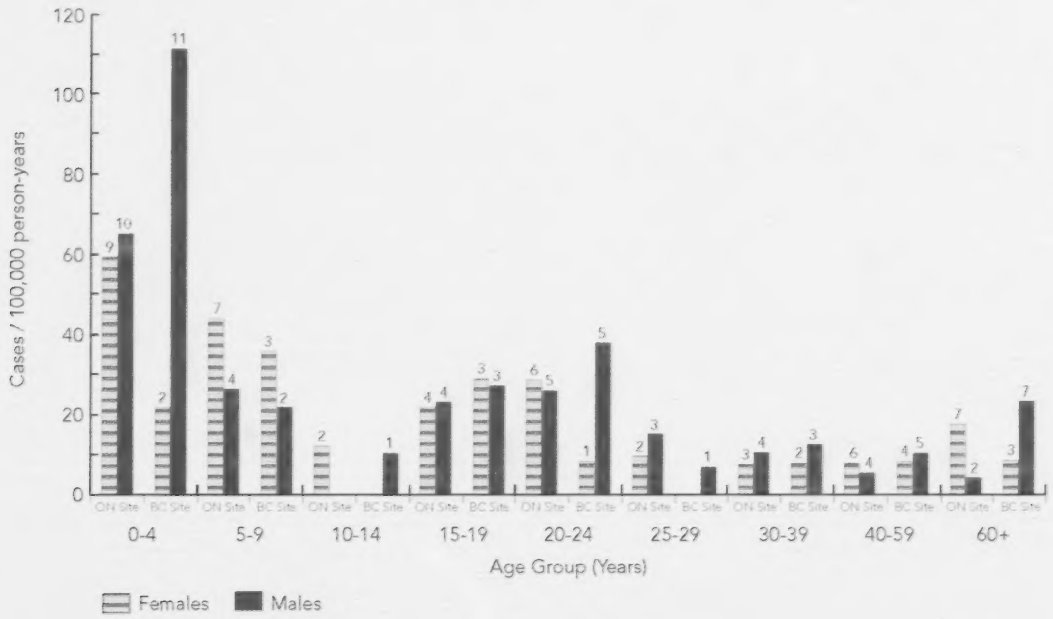
Regardless of sentinel site or epidemiological classification (i.e. endemic, outbreak, or travel-related), the most commonly reported serovars of *Salmonella* were Enteritidis (49%; 110/225), Typhimurium (15%; 34/225), and Heidelberg (7%; 16/225). These serovars were also the same top three reported to the National Enteric Surveillance Program in 2010 (*3*). Of the cases attributed to *S.* Enteritidis, 63% (66 endemic and three outbreak cases) were classified as domestically acquired. Of those attributed to *S.* Typhimurium, 88% (27 endemic and three outbreak cases) were domestically acquired, as were 94% (13 endemic and two outbreak) of cases attributed to *S.* Heidelberg infection.

Distributions of patient age, patient gender, and season among the salmonellosis cases in 2010 were similar to those observed historically in the ON site (Figure 4.1). Salmonellosis is most commonly reported among children less than 10 years of age.

Among the 82 endemic cases in the ON site, 17 serovars were identified. The top three *Salmonella* serovars were Enteritidis, Heidelberg, and Typhimurium, which comprised 78% (64/82) of serotyped isolates.

Similarly, 16 serovars were detected among *Salmonella* isolates from the 56 endemic cases in the BC site in 2010. The top three serovars were identical to those in the ON site and comprised 75% (42/56) of the isolates (Table 4.1). Only three other serovars were common to both sentinel sites: Brandenburg, Newport, and Stanley.

FIGURE 4.1. Incidence rates of human endemic salmonellosis in the ON and BC sites in 2010, by gender and age group.



NOTE: The number of cases is included above each bar.

4.2 Travel-Related Cases

The most commonly isolated *Salmonella* serovars for travel-related cases in the ON site were Enteritidis (54%; 21/39), Infantis (15%; 6/39), and Typhimurium (8%; 3/39). The most commonly isolated travel-related serovars in the BC site were Enteritidis (63%; 20/32), followed by Paratyphi B var. Java (6%; 2/32), and Agona (6%; 2/32).

In total, in both sites, 63% (45/71) of people with travel-related salmonellosis reported travel to the Americas (South or Central locations), whereas 45% (11/71) reported travelling to Asia and 4% (3/71) to the United States. The remaining 12 people with travel-related disease had travelled to Europe, Africa, or other/multiple countries. Of the 41 travel-related *S.* Enteritidis cases, 80% (33/41) had a history of travel to the Americas (South or Central locations).

4.3 Case Exposures

Information was collected for 85% (70/82) of endemic salmonellosis cases in the ON site regarding exposure to potential sources of infection in the three days prior to the onset of illness (Appendix B.1).

In the BC site, 93% (52/56) of endemic salmonellosis cases had potential exposure information for the three days prior to onset of illness (Appendix B.2). A higher proportion of salmonellosis cases than other diseases cases had a history of contact with household cats (43%).

4.4 Surveillance of Potential Sources

Food

Salmonella was detected in 29% (57/197) of skinless chicken breast samples collected in 2010 from retail establishments in the ON site (Table 4.1). The pathogen was rarely detected on retail pork chops (2% of samples) or ground beef (1% of samples). This prevalence of contamination is identical to the prevalence observed in 2009 in the same site. Also consistent with findings in previous years is the observation that overall numbers of *Salmonella* organisms in *Salmonella*-positive samples were consistently low (Appendix C).

The three most common *Salmonella* serovars detected in chicken breast samples were Kentucky, Heidelberg, and Enteritidis.

In the ON site, 168 samples of bagged leafy greens collected from retail establishments (following the same protocol as for raw meat) were tested for *Salmonella* (Table 10.1). No *Salmonella* was recovered from any of these samples.

Farm animals

Consistent with findings in previous surveillance years, the prevalence of *Salmonella* in pooled fecal samples from swine remained at approximately 24% (Table 4.1). On the other hand, the prevalence of *Salmonella* in samples of broiler chicken feces increased from 31% in 2009 to 63% in 2010.

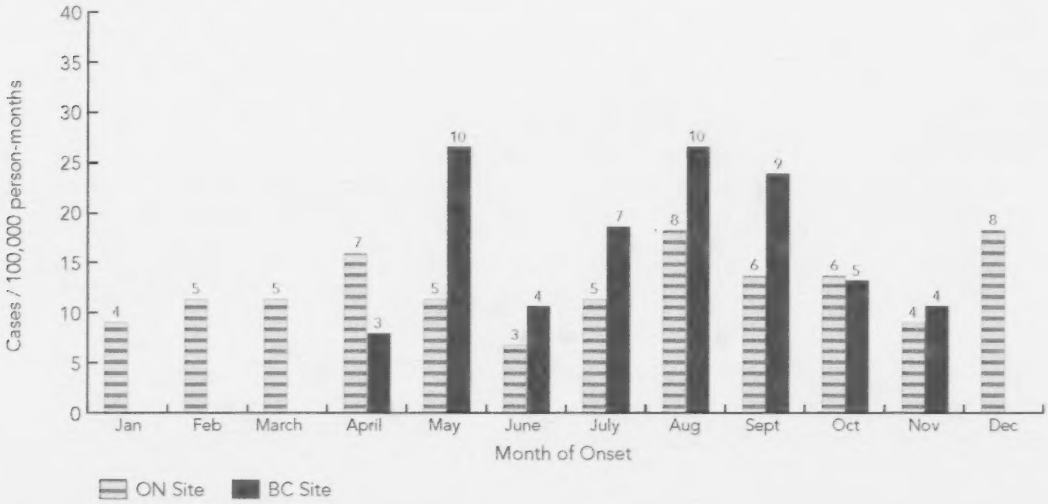
Water

Salmonella was detected in 24% of surface water samples collected from the Grand River in 2010. These positive samples originated from all five sites. Historically, FoodNet Canada has observed similar levels at all monitoring sites. Watersheds are expected to be impacted by fecal contamination from both point and non-point sources such as wastewater treatment plants, septic systems, wildlife and agriculture. It is known that the Grand River is a heavily impacted watershed. Drinking water treatment in this sentinel site is designed to treat these water conditions.

4.5 Temporal Distribution

In the ON site in 2010, the incidence rate of endemic salmonellosis was higher during the spring (March, April, and May), summer (June, July, and August), and fall (September, October, and November) than during the winter (December, January, and February); however, the difference was not statistically significant (Figure 4.2). In the BC site, because data were only collected for a partial year, seasonal variation was not evaluated.

FIGURE 4.2. Distribution of reported human endemic cases of salmonellosis in the ON and BC sites in 2010, by month.



NOTE: The number of cases is indicated above each bar.

4.6 Subtype Comparison

One of the benefits of the FoodNet Canada surveillance system is the application of laboratory subtyping methodologies to identify patterns in subtype distributions among both the human cases and potential sources over time (Table 4.1). In this section, data on the top three serovars associated with human *Salmonella* infection for all of Canada and in the ON and BC sites are more thoroughly presented, by phage type or pulsed-field gel electrophoresis (PFGE) pattern, and key trends are identified.

Salmonella Typhimurium

Typhimurium continued to be the most common *Salmonella* serovar detected in swine feces. It was also one of the top three serovars associated with reported human cases of salmonellosis in the ON and BC sites and in all of Canada in 2010 (*7*). Some patterns are common between cases and exposure sources (Table 4.2). Phage type 104/104a was detected in fecal samples from broiler chicken and beef cattle farms and in two retail chicken samples. The same phage type was linked to one travel-related and three domestic cases of salmonellosis in 2010. Retail pork chops are not typically contaminated with *Salmonella*; therefore, collection of pork samples was stopped in 2011 (*8*).

Salmonella Enteritidis

The incidence of human cases of *Salmonella* Enteritidis infection is continuing to increase in Canada, and has since mid-2008 (*9*). The serovar is common among travel- and non-travel-related cases (including endemic and outbreak-related cases), yet particular phage types (PTs) are more common among endemic cases, including PT8, PT13, and PT13A (Table 4.3). In contrast, PT1 and PT4 are more likely to be the cause of travel-related cases. One of the main

sources of endemic *S.* Enteritidis infection is believed to be poultry products, including eggs and chicken meat (*9*). The FoodNet Canada surveillance data from 2010 (and 2009) support this supposition: PT8, PT13, and PT13A were detected in samples of retail chicken and broiler chicken feces. In 2005, a high incidence of PT13 infection was attributed to a province-wide outbreak associated with the consumption of bean sprouts, that resulted in 40 cases being reported in the ON site (of the total 552 cases reported throughout Ontario).

Salmonella Heidelberg

Data on *Salmonella* Heidelberg are presented by phage type (Table 4.4) and PFGE pattern (Table 4.5) to illustrate the different patterns observed with these available subtyping methods. *S.* Heidelberg is the most common serovar in samples of retail chicken breasts and on broiler chicken farms. A broad distribution of phage types and PFGE patterns was found among isolates recovered from retail chicken meat.

Some alignment appears to have existed in 2010 among phage types of *Salmonella* Heidelberg isolates recovered from human non-travel cases (including endemic and outbreak-related cases) and retail chicken meat for PT19, and among human non-travel cases and broiler chicken feces for PT29 (Table 4.4). Conversely, this commonality was not observed as clearly in PFGE patterns, as most isolates shared the same PFGE pattern (SHEXAI.0001) regardless of source. This particular PFGE pattern is common in human cases of infection, both in the ON site and nationally (*7*).

Other Serovars

Salmonella Kentucky was commonly recovered from samples of retail chicken meat (58% [33/57] of *Salmonella* isolates), broiler chicken feces (63% [47/75] of isolates), and beef cattle feces (33% [5/15] isolates; Table 4.1). The serovar was also occasionally detected in surface water samples, but it was not found among human cases of salmonellosis (no cases of *S.* Kentucky infection were detected in 2010 in either site). This situation has been seen at the ON site since 2005 when the surveillance began (*8*). The epidemiology of *S.* Kentucky is important to understand, since surveillance data suggest the organism is prevalent in several potential exposure sources, yet it does not contribute to the human burden of salmonellosis.

In 2010, *S.* Cerro was most commonly detected in dairy cattle fecal samples (as observed in previous years), yet was not associated with any human cases in the ON or BC sites. This particular serovar is uncommon nationally (*10*).

TABLE 4.1. Number (%) of *Salmonella* detected and serotyped (culture-based methods) through integrated surveillance activities in the ON site in 2010, with human case information for the BC site provided for comparison.

METHOD	HUMAN		RETAIL			ON-FARM[a]				WATER[b]
	Endemic cases ON site	Endemic cases BC site	Pork chops	Chicken breasts	Ground beef	Swine	Broiler chickens	Beef cattle	Dairy cattle	
Detection										
No. of samples tested	Unknown	Unknown	197	197	197	120	120	119	120	94
No. (%) positive	82	56	3 (2%)	57 (29%)	1 (1%)	29 (24%)	75 (63%)	15 (13%)	15 (13%)	23 (24%)
Serotyping										
No. of isolates serotyped	82	56	2	57	1	29	75	15	15	23
Agona	0	0	0	0	0	5	0	1	0	1 (site E)
Albany	0	1	0	0	0	0	0	0	0	1 (site B)
Berta	0	0	0	1	0	0	0	0	1	1 (site A)
Braenderup	0	0	0	0	0	1	0	0	0	1 (site E)
Brandenburg	1	1	0	0	0	0	0	0	0	0
Cerro	0	0	0	0	0	0	0	4	7	0
Derby	0	0	0	0	0	6	0	0	0	0
Enteritidis	37	29	0	6	0	0	4	3	0	0
Give	0	0	0	0	0	1	0	0	0	2 (site A)
Hadar	0	0	0	1	0	0	4	0	0	1 (site E)
Heidelberg	10	3	0	12	0	0	4	1	3	0
I:Rough-O:i:z6:-i:z6	0	0	0	0	0	0	5	0	0	1 (site A)
IIIb:11:k:-11:k:-	0	0	0	0	0	0	0	0	0	2 (sites B, E)
Infantis	0	1	1	0	0	1	0	0	0	2 (site E)
Kentucky	0	0	1	30	1	0	47	5	2	1 (site B)
London	0	0	0	0	0	3	0	0	0	1 (site C)
Newport	2	1	0	0	0	0	0	0	0	4 (sites B, D, E)
I:4,5,12:b:-	3	0	0	0	0	0	0	0	0	0
I:4,5,12:i	0	2	0	0	0	0	0	0	0	0
Paratyphi B var. Java	0	2	0	0	0	0	0	0	0	0
Schwarzengrund	1	0	0	0	0	0	1	0	0	0

METHOD	HUMAN		RETAIL			ON-FARM[a]				WATER[b]
	Endemic cases ON site	Endemic cases BC site	Pork chops	Chicken breasts	Ground beef	Swine	Broiler chickens	Beef cattle	Dairy cattle	
Stanley	**1**	**1**	0	0	0	0	0	0	0	0
Thompson	**1**	0	0	**1**	0	0	0	0	**1**	**2 (sites D,E)**
Typhimurium	**17**	**10**	0	**4**	0	**1**	**7**	**1**	0	0
Typhimurium var. Copenhagen 4:i:1,2	0	0	0	0	0	**8**	0	0	**1**	**1 (site A)**
Uganda	**2**	0	0	0	0	0	0	0	0	0
Worthington	0	0	0	0	0	**1**	**3**	0	0	0
Other[c]	**8**	**6**	0	**2**	0	**2**	**1**	0	0	**3**

[a] Fecal samples were collected from 30 farms in the ON site for each type of food animal.

[b] Samples of untreated surface water were collected from five sites along the Grand River in the ON site: Canagagigue Creek (A), Conestogo River (B), Upper Grand River (C), Grand River, near drinking water intake (D), and Grand River, near a wastewater treatment plant effluent point (E).

[c] Serovars that were identified once in a single component are listed here rather than in the table:

- Human, ON site: Hartford, Hvittingfoss, Javiana, Poona, Saintpaul, Sandiego, Singapore
- Human, BC site: Daytona, Hessarek, Mbandaka, Muenchen, SS IIIA Arizonae
- Retail chicken: ssp. I:4,12:-:1,2 4:-:1,2, ssp. I:8:20:-:z6 8,20:-:z6
- Swine farms: ssp. I:23:z:-23:z:-, Livingstone var. 14+6,7,14:d:l,w
- Untreated water: Butantan (site E), ssp. I:4,5,12:-:- 4,5:-:- (site D)

TABLE 4.2. Integrated comparison of the number of various phage types of *Salmonella* Typhimurium isolated through surveillance activities in 2010 versus in 2005 through 2009.

PHAGE TYPE	HUMAN				RETAIL			ON-FARM[b]				WATER[c]
	Travel ON site	Non-travel[a] ON site	Travel BC site	Non-travel[a] BC site	Pork chops	Chicken breasts	Ground beef	Swine	Broiler chickens	Beef cattle	Dairy cattle	
PT1	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT2	0 (0)	0 (1)	0 (-)	**1 (-)**	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)
PT3	0 (0)	0 (4)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT8	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT10	0 (0)	**1 (2)**	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT12/12A	0 (0)	0 (4)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (2)	**1 (0)**	0 (0)	0 (0)	0 (0)
PT15/15A	0 (0)	0 (0)	0 (-)	**2 (-)**	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)
PT21	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT22	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT28	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)
PT40	0 (0)	0 (0)	**1 (-)**	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT41	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)
PT46	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)
PT51	0 (1)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT66	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT69	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)
PT82	0 (0)	0 (2)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT97	0 (0)	0 (2)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT104/104A	**1 (0)**	**3 (7)**	0 (-)	0 (-)	0 (2)	**2 (3)**	0 (0)	**2 (30)**	**2 (3)**	0 (2)	0 (6)	0 (2)
PT104B	0 (0)	0 (4)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	**4 (6)**	0 (0)	**1 (0)**	**1 (0)**	**1 (0)**
PT108	0 (1)	0 (21)	0 (-)	0 (-)	0 (0)	**2 (5)**	0 (0)	1 (0)	**2 (1)**	0 (0)	0 (0)	0 (5)
PT117	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT120	0 (1)	0 (2)	0 (-)	0 (-)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT135	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT151	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)

PHAGE TYPE	HUMAN				RETAIL			ON-FARM[b]				WATER[c]
	Travel ON site	Non-travel[a] ON site	Travel BC site	Non-travel[a] BC site	Pork chops	Chicken breasts	Ground beef	Swine	Broiler chickens	Beef cattle	Dairy cattle	
PT160	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)
PT169	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT170	0 (0)	**3 (4)**	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	**1 (0)**	0 (0)	0 (0)	0 (0)
PT193	**1 (0)**	0 (2)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (1)
PT194	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)
PT208	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (3)	0 (0)	0 (0)	0 (0)	0 (0)
PT1106	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PTU211a	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PTU285	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PTU302	0 (0)	**6 (1)**	0 (-)	0 (-)	0 (1)	0 (0)	0 (0)	0 (6)	0 (0)	0 (1)	0 (1)	0 (0)
PTU310	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PTU311	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (1)
PTUT1	0 (0)	0 (1)	0 (-)	**1 (-)**	0 (0)	0 (0)	0 (0)	**1 (3)**	0 (0)	0 (0)	0 (0)	0 (0)
PTUT5	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)
Untypable	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (4)	0 (0)	0 (0)	0 (1)	0 (0)
Atypical	0 (0)	**1 (2)**	0 (-)	**1 (-)**	0 (0)	0 (1)	0 (0)	**1 (0)**	**1 (0)**	0 (0)	0 (0)	0 (2)
Total no. of isolates typed	**2 (3)**	**14 (68)**	**1 (-)**	**5 (-)**	**0 (4)**	**4 (15)**	**0 (0)**	**9 (68)**	**7 (4)**	**1 (4)**	**1 (8)**	**1 (13)**

Data in parentheses are the sum of all isolates obtained from 2005–2009.

[a] Non-travel cases include endemic and outbreak-related cases.

[b] Fecal samples were collected from 30 farms in the ON site for each type of food animal.

[c] Samples of untreated surface water were collected from five sites along the Grand River in the ON site: Canagagigue Creek, Conestogo River, Upper Grand River, Grand River, near drinking water intake, and Grand River, near a wastewater treatment plant effluent point.

TABLE 4.3. Integrated comparison of the number of various phage types of *Salmonella* Enteritidis isolated through surveillance activities in 2010 versus in 2005 through 2009.

PHAGE TYPE	HUMAN				RETAIL			ON-FARM[b]				WATER[c]
	Travel ON site	Non-travel[a] ON site	Travel BC site	Non-travel[a] BC site	Pork chops	Chicken breasts	Ground beef	Swine	Broiler chickens	Beef cattle	Dairy cattle	
PT1	**5 (8)**	**1 (0)**	**1 (-)**	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT1A	0 (2)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT2	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)
PT4	**2 (10)**	0 (3)	**1 (-)**	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT4A	0 (1)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT5B	0 (9)	0 (2)	**2 (-)**	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT6	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT6A	0 (4)	0 (1)	**2 (-)**	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT6D	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT7A	**1 (0)**	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT8	0 (3)	**9 (26)**	**3 (-)**	**18 (-)**	0 (0)	**3 (1)**	0 (0)	0 (0)	0 (3)	0 (1)	0 (0)	0 (0)
PT8A	0 (0)	0 (0)	0 (0)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)
PT12	0 (0)	0 (0)	**1 (-)**	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT13	**1 (0)**	**2 (57)**[d]	**1 (-)**	0 (-)	0 (0)	0 (8)	0 (1)	0 (1)	0 (3)	**2 (0)**	0 (0)	0 (2)
PT13A	**1 (3)**	**13 (14)**	**4 (-)**	**5 (-)**	0 (0)	**3 (3)**	0 (0)	0 (0)	**4 (2)**	0 (0)	0 (0)	0 (0)
PT14B	0 (1)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT19	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)
PT21	0 (2)	0 (1)	**1 (-)**	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT22	0 (0)	**2 (1)**	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)
PT37	0 (1)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT41	**1 (0)**	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT51	0 (0)	**1 (0)**	0 (-)	**3 (-)**	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT55	**1 (0)**	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT911	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

PHAGE TYPE	HUMAN				RETAIL			ON-FARM[b]				WATER[c]
	Travel ON site	Non-travel[a] ON site	Travel BC site	Non-travel[a] BC site	Pork chops	Chicken breasts	Ground beef	Swine	Broiler chickens	Beef cattle	Dairy cattle	
Atypical	**1 (2)**	**1 (2)**	**1 (-)**	**2 (-)**	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	**1 (0)**	0 (0)	0 (0)
Untypable	**1 (0)**	0 (0)	**2 (-)**	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total no. of isolates typed[e]	**14 (46)**	**29 (111)**	**19 (-)**	**28 (-)**	**0 (0)**	**6 (24)**	**0 (1)**	**0 (0)**	**4 (13)**	**3 (1)**	**0 (0)**	**0 (3)**

Data in parentheses are the sum of all isolates identified as the indicated phage type from 2005–2009.

[a] Non-travel cases include endemic and outbreak-related cases.

[b] Fecal samples were collected from 30 farms in the ON site for each type of food animal.

[c] Samples of untreated surface water were collected from five sites along the Grand River in the ON site: Canagagigue Creek, Conestogo River, Upper Grand River, Grand River, near drinking water intake, and Grand River, near a wastewater treatment plant effluent point.

[d] An outbreak of *Salmonella* Enteritidis PT13 infection in 2005 resulted in 40 cases reported to the ON site.

[e] The total number of isolates reported in the table for 2005–2009 may not correspond to the total number of isolates subtyped because only phage types identified in 2010 are included.

TABLE 4.4. Integrated comparison of the number of various phage types of *Salmonella* Heidelberg isolated through surveillance activities in 2010 versus in 2005 through 2009.

PHAGE TYPE	HUMAN				RETAIL			ON-FARM[b]				WATER[c]
	Travel ON site	Non-travel[a] ON site	Travel BC site	Non-travel[a] BC site	Pork chops	Chicken breasts	Ground beef	Swine	Broiler chickens	Beef cattle	Dairy cattle	
PT2	0 (0)	0 (2)	0 (-)	0 (-)	0 (0)	0 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT4	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)
PT5	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (7)	0 (0)	0 (0)	**1 (0)**	0 (0)	0 (0)	0 (0)
PT9	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT10	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT11	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT11a	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)
PT16	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT17	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	**2 (1)**	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)

PHAGE TYPE	HUMAN				RETAIL			ON-FARM[b]				WATER[c]
	Travel ON site	Non-travel[a] ON site	Travel BC site	Non-travel[a] BC site	Pork chops	Chicken breasts	Ground beef	Swine	Broiler chickens	Beef cattle	Dairy cattle	
PT18	0 (0)	0 (2)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	**3 (0)**	0 (0)
PT19	0 (0)	**8 (9)**	0 (-)	0 (-)	0 (0)	**3 (20)**	0 (0)	0 (0)	0 (1)	0 (1)	0 (0)	0 (1)
PT19a	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	**2 (1)**	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT22	**1 (0)**	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT25	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT26	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	**2 (1)**	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT29	0 (0)	**2 (1)**	0 (-)	0 (-)	0 (0)	0 (5)	0 (0)	0 (0)	**1 (2)**	0 (0)	0 (0)	0 (0)
PT29A	0 (0)	0 (0)	0 (-)	**1 (-)**	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT35	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT39	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT41	0 (0)	0 (3)	0 (-)	0 (-)	0 (0)	**2 (1)**	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
PT46	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	**1 (0)**	0 (0)	0 (0)	0 (5)	0 (0)	0 (0)	0 (0)
PT52	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Atypical	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (2)	0 (0)	0 (0)	**2 (1)**	**1 (0)**	0 (0)	0 (0)
Untypable	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total no. of isolates typed[d]	**1 (0)**	**10 (21)**	**0 (-)**	**1 (-)**	**0 (0)**	**12 (56)**	**0 (0)**	**0 (0)**	**4 (10)**	**1 (2)**	**3 (0)**	**0 (2)**

Data in parentheses are the sum of all isolates identified as the indicated phage type from 2005–2009.

[a] Non-travel cases include endemic and outbreak-related cases.

[b] Fecal samples were collected from 30 farms in the ON site for each type of food animal.

[c] Samples of untreated surface water were collected from five sites along the Grand River in the ON site: Canagagigue Creek, Conestogo River, Upper Grand River, Grand River, near drinking water intake, and Grand River, near a wastewater treatment plant effluent point.

[d] The total number of isolates reported in the table for 2005–2009 may not correspond to the total number of isolates subtyped because only phage types identified in 2010 are included.

TABLE 4.5. Integrated comparison of the number of *Salmonella* Heidelberg isolates with various pulsed-field gel electrophoresis (PFGE) patterns identified through surveillance activities in 2010 versus in 2005 through 2009.

PATTERN	HUMAN				RETAIL			ON-FARM[b]				WATER[c]
	Travel ON site	Non-travel[a] ON site	Travel BC site	Non-travel[a] BC site	Pork chops	Chicken breasts	Ground beef	Swine	Broiler chickens	Beef cattle	Dairy cattle	
SHEXAI.0001	0 (0)	**7 (4)**	0 (-)	**2 (-)**	0 (0)	**6 (29)**	0 (0)	0 (0)	**2 (10)**	**1 (1)**	**3 (0)**	0 (1)
SHEXAI.0006	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)
SHEXAI.0007	0 (0)	**1 (8)**	0 (-)	0 (-)	0 (0)	0 (3)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)
SHEXAI.0009	0 (0)	0 (4)	0 (-)	**1 (-)**	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0011	0 (0)	0 (2)	0 (-)	0 (-)	0 (0)	**1 (8)**	0 (0)	0 (0)	**2 (0)**	0 (0)	0 (0)	0 (0)
SHEXAI.0012	**1 (0)**	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0015	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0020	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	**4 (9)**	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0139	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	**1 (1)**	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0187	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0194	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0201	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SHEXAI.0204	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total no. of isolates typed[d]	**1 (0)**	**8 (21)**	**0 (-)**	**3 (-)**	**0 (0)**	**12 (60)**	**0 (0)**	**0 (0)**	**4 (10)**	**1 (2)**	**3 (0)**	**0 (2)**

Data in parentheses are the sum of all isolates identified as the indicated pattern from 2005–2009.

[a] Non-travel cases include endemic and outbreak-related cases.

[b] Fecal samples were collected from 30 farms in the ON site for each type of food animal.

[c] Samples of untreated surface water were collected from five sites along the Grand River in the ON site: Canagagigue Creek, Conestogo River, Upper Grand River, Grand River, near drinking water intake, and Grand River, near a wastewater treatment plant effluent point.

[d] The total number of isolates reported in the table for 2005–2009 may not correspond to the total number of isolates that underwent PFGE because only patterns identified in 2010 are included.

4.7 Summary of *Salmonella* Results

What is the same in 2010 as in previous years?

- Distributions of human salmonellosis cases by patient age, patient gender, and season were similar to historical distributions in the ON site.
- Regardless of sentinel site or disease classification (endemic, outbreak, or travel-related), the most commonly reported serovars for human cases of salmonellosis were Enteritidis (49%; 110/225), Typhimurium (15%; 34/225), and Heidelberg (7%; 16/225).
- *Salmonella* Kentucky continued to be the most common serovar recovered from samples of retail skinless chicken breasts, ground beef, and broiler chicken and beef cattle feces, though was not associated with any human cases.
- Phage type alignment continues to be observed among isolates from endemic human cases, chicken meat, and broiler chicken feces for both *Salmonella* Heidelberg and *Salmonella* Enteritidis.

What is new?

- The incidence of human salmonellosis in the ON site appeared to increase in early spring and late summer in 2010.
- The prevalence of *Salmonella* in broiler chicken fecal samples increased from 31% in 2009 to 63% in 2010. Possible reasons for the increase are unclear. Continued monitoring and investigation will help to further understand this finding. *Salmonella* is typically observed in broiler chicken fecal samples. During this time, a similar increasing trend in humans, in *S.* Enteritidis in particular, was observed throughout Canada (*9*).

What impact does this have on public health?

- The data on retail food contamination with *Salmonella* will be used to develop several evaluation tools for generating risk profiles, ranking risks to the Canadian consumer, and ultimately informing the development of policies such as a pathogen reduction strategy.
- The results for fecal samples from farms and results from water samples are being used to inform the development of source tracking studies and a national attribution model for *Salmonella* transmission as well as to understand the environmental prevalence of these pathogens.

5. PATHOGENIC *ESCHERICHIA COLI*

5.1 Human Cases

In 2010 in the ON site, 12 cases of verotoxigenic *Escherichia coli* (VTEC) infection were reported, for an incidence rate of 2.3 cases/100,000 person-years. All cases were attributed to *E. coli* strain O157:H7 and all were classified as endemic.

The BC site reported 10 cases of VTEC infection between April and December 2010, for an incidence rate of 3.0 cases/100,000 person-years. The following strains were identified: *E. coli* O157:H7 (4 cases), *E. coli* O157:non-motile (1 case), *E. coli* verotoxin positive only (2 cases), *E. coli* O121:H19 (2 cases), and *E. coli* O111:NM (1 case). Of these 10 cases, one (0.3 cases/100,000 person-years) was travel-related and nine (2.7 cases/100,000 person-years) were classified as endemic.

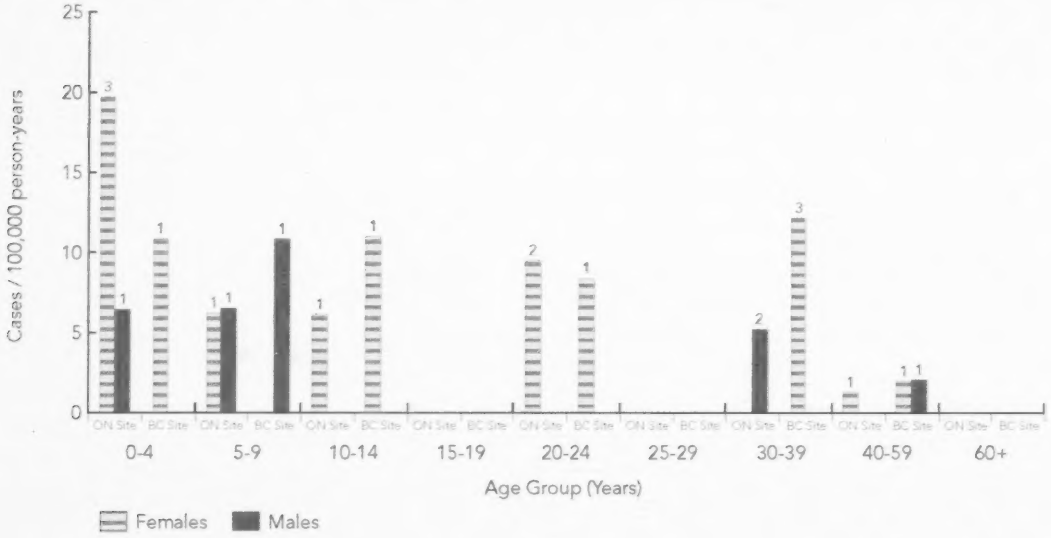
In comparison, the annual incidence rates for VTEC infection in 2010 for all of Canada, Ontario, and British Columbia specifically were 1.6, 1.1 and 2.4 cases/100, 000 person-years, respectively (**4**). According to NESP data, the higher incidence rate in British Columbia may partly be due to a larger number of non-O157 strains reported in the province (as observed in the sentinel site), compared to Ontario where the majority of *E.coli* infections reported to NESP in 2010 were due to *E.coli* O157:H7 (**3**).

Among the 12 endemic cases from the ON site in 2010, females less than five years of age represented the most commonly affected group (Figure 5.1).

Among the 9 individuals with endemic VTEC infection in the BC site, females between the ages of 30 and 39 years were most likely to be affected (Figure 5.1).

With data from both sentinel sites combined, females were more likely to have a VTEC infection than males (15 cases in females vs. 6 in males). The age distribution was different between the sites with most cases being less than 15 years of age in ON, whereas in the BC site, there were twice as many cases 15 years of age or older (6 cases) than those that were less than 15 years of age (3 cases).

FIGURE 5.1. Incidence rates of human endemic *E. coli* O157:H7 infection in the ON site and VTEC infection in the BC site in 2010, by gender and age group.



NOTE: The number of cases is indicated above each bar.

5.2 Case Exposures

In the ON site, exposure information for the 10 days prior to the onset of illness was reported for all 100% (12/12) of the endemic cases of *E. coli* O157:H7 infection (Appendix B.1). A higher proportion of *E. coli* O157:H7 cases than other disease cases had a history of eating in a restaurant (58%). This higher proportion does not necessarily mean that the risk associated with the exposure is high, but highlights areas to research further in order to better understand potential sources.

In the BC site, exposure information was reported for seven of the nine endemic cases of VTEC infection (Appendix B.2). Given that there were less than 10 cases with exposure data, no exposure factors have been highlighted.

5.3 Surveillance of Potential Sources

Food

In the retail component, the method for isolating verotoxigenic *E. coli* from samples of retail ground beef was modified to increase test sensitivity, which resulted in a significant increase in the apparent prevalence of VTEC among ground beef samples. Verotoxigenic *E. coli* was isolated from 6% (12/197) of retail beef samples (Table 5.1). The pathogen was not detected in retail pork or chicken samples.

Farm animals

Escherichia coli O157:H7 was isolated from 13% (15/119) of pooled fecal samples collected from beef cattle farms and from 6% (7/120) of pooled fecal samples collected from dairy cattle farms (Table 5.1). These samples were obtained from 30% (9/30) and 20% (6/30) of beef and dairy farms involved in the surveillance program. None of the fecal samples from broiler chickens were positive for *E. coli* O157:H7, which is consistent with findings in previous years. The pathogen was isolated from 3% (4/120) of swine fecal samples, collected from 10% (3/30) of participating swine farms. On one swine operation, *E. coli* O157:H7 was detected in a sample obtained from a manure pit; however, given that this operation also included sheep and horses, the source of the organism could not be determined.

Water

Halfway through 2010, a new method was put into place to detect all strains of VTEC in untreated surface water samples. This method was performed in parallel with the traditional *E. coli* O157:H7 testing of water samples.

Verotoxigenic *E. coli* was detected in 2% (3/94) of water samples from all five sites along the Grand River in 2010 (multiple subtypes were detected in some samples). Each of the three isolates had a different serotype (O157:H7, O109:NM, and O111:H8).

5.4 Subtype Comparison

Use of pulsed-field gel electrophoresis (PFGE) revealed 37 isolates comprising 26 distinct patterns among the *E. coli* O157:H7 isolates recovered in 2010. One human endemic case in the ON site (ECXAI.0001) had a PFGE pattern that was shared with that of a fecal isolate from a beef farm (Table 5.2). A table of all *E. coli* PFGE patterns detected through all FoodNet Canada surveillance components from 2005 through 2009 is provided for reference in Appendix D. Interestingly, this ECXAI.0001 pattern was the most common human clinical isolate of VTEC reported to PulseNet Canada for 2010.

One human case of *E. coli* O157:H7 infection was associated with the PFGE pattern ECXAI.0008, which is the third most common pattern in the PulseNet Canada database (associated with 10 human cases of infection in all of Canada in 2010).

When five years of surveillance data were compared, very little commonality was identified among sources in PFGE patterns. Some commonality was observed between dairy and beef cattle isolates, and in one year, one of the associated PFGE patterns was also detected in a surface water sample. These findings were expected, as considerable diversity appears to be typical of *E. coli* O157:H7 PFGE patterns, both nationally (7) and within the FoodNet Canada system.

TABLE 5.1. Number (%) of verotoxigenic *Escherichia coli* isolates detected and identified through integrated surveillance activities in the ON site in 2010, with human case information for the BC site provided for comparison.

RESULT	HUMAN		RETAIL			ON-FARM[a]				WATER[b]
	Endemic cases ON site	Endemic cases BC site	Pork chops	Chicken breasts	Ground beef	Swine	Broiler chickens	Beef cattle	Dairy cattle	
No. of samples tested	Unknown	Unknown	197	197	197	120	120	119	120	94
No. (%) positive	12	9	0 (0%)	0 (0%)	12 (6%)	4 (3%) from 3 farms	0 (0%)	15 (13%) from 9 farms	7 (6%) from 6 farms	3 (2%)
No. untyped	0	0	0	0	12	0	0	0	0	NT
No. of non-O157	0	4	NT	NT	NT	NT	NT	NT	NT	2 from B,E
No. of O157 non-H7	0	1	NT	NT	NT	3	0	0	0	0
No. of O157:H7	12	4	NT	NT	NT	1	0	15	7	3 from A,E

NT = Not tested.

[a] Fecal samples were collected from 30 farms in the ON site for each type of food animal.

[b] Samples of untreated surface water were collected from five sites along the Grand River in the ON site: Canagagigue Creek (A), Conestogo River (B), Upper Grand River (C), Grand River, near drinking water intake (D), and Grand River, near a wastewater treatment plant effluent point (E).

TABLE 5.2. Number of *Escherichia coli* O157:H7 isolates with various pulsed-field gel electrophoresis (PFGE) patterns identified through surveillance activities in 2010 versus in 2005 through 2009.

PATTERN	HUMAN				ON-FARM[b]			WATER[c]
	Travel ON site	Non-travel[a] ON site	Travel BC site	Non-travel[a] BC site	Swine	Beef cattle	Dairy cattle	
ECXAI.0001	0 (0)	**1 (6)**	0 (-)	0 (-)	0 (0)	**1 (2)**	0 (1)	0 (0)
ECXAI.0006	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (3)	0 (0)	0 (0)
ECXAI.0008	0 (0)	0 (3)	0 (-)	0 (-)	0 (0)	**1 (1)**	0 (1)	0 (1)
ECXAI.0014	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	**2 (0)**	0 (0)	0 (0)
ECXAI.0017	0 (0)	0 (3)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.0052	0 (1)	0 (3)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.0221	0 (0)	**1 (1)**	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.0262	0 (0)	0 (9)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.0266	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (2)	0 (0)	0 (0)
ECXAI.0407	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (2)	0 (0)	0 (0)
ECXAI.0825	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (3)	0 (0)	0 (0)
ECXAI.1164	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (1)	**1 (0)**	0 (0)

PATTERN	HUMAN				ON-FARM[b]			WATER[c]
	Travel ON site	Non-travel[a] ON site	Travel BC site	Non-travel[a] BC site	Swine	Beef cattle	Dairy cattle	
ECXAI.1175	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (2)	0 (0)
ECXAI.1182	0 (0)	**1 (0)**	0 (-)	0 (-)	0 (0)	0 (0)	0 (1)	0 (0)
ECXAI.1221	0 (0)	0 (6)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.1267	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (1)	0 (1)	0 (0)
ECXAI.1288	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	**3 (0)**	0 (0)	0 (0)
ECXAI.1301	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	**1 (1)**	0 (0)	0 (0)
ECXAI.1577	0 (0)	0 (2)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.1612	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (2)	0 (0)
ECXAI.1687	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	0 (2)	0 (0)
ECXAI.1692	0 (0)	0 (1)	0 (-)	0 (-)	0 (0)	0 (0)	0 (1)	0 (0)
ECXAI.1694	0 (0)	**2 (1)**	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.1737	0 (0)	0 (2)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.1898	0 (0)	0 (2)	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.2110	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (2)	0 (0)	0 (0)
ECXAI.2353	0 (0)	**2 (0)**	0 (-)	0 (-)	0 (0)	0 (0)	0 (0)	0 (0)
ECXAI.2330	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (2)	0 (0)	0 (0)
ECXAI.2464	0 (0)	0 (0)	0 (-)	0 (-)	0 (0)	0 (0)	**2 (0)**	0 (0)
Other	0 (2)	**2 (28)**	0 (-)	**4 (-)**	**1 (0)**	**7 (12)**	**4 (21)**	**2 (1)**
No. of isolates with results	**0 (3)**	**9 (69)**	**0 (-)**	**4 (-)**	**1 (0)**	**15 (32)**	**7 (32)**	**3 (2)**

Data in parentheses are the sum of all isolates obtained from 2005–2009.

[a] Non-travel cases include endemic and outbreak-related cases.

[b] Fecal samples were collected from 30 farms in the ON site for each type of food animal.

[c] Samples of untreated surface water were collected from five sites along the Grand River in the ON site: Canagagigue Creek, Conestogo River, Upper Grand River, Grand River, near drinking water intake, and Grand River, near a wastewater treatment plant effluent point.

5.5 Temporal Distribution

In the ON site, 12 human endemic cases of VTEC infection were reported between March and November, 2010. The highest number of cases (three per month) was reported in August and September.

5.6 Summary of Pathogenic *E. coli* Results

- Verotoxigenic *E. coli* (O157:H7 and non-O157:H7 serotypes) infections continued to be domestically acquired rather than travel-related in 2010. Of the 17 reported cases in the sentinel sites, only one was associated with travel.
- No commonality of PFGE patterns were detected among the human and non-human isolates from 2010, suggesting that a large diversity of strains are circulating in the sentinel sites, which is also noted nationally in human cases. Little commonality was also evident when data were reviewed from multiple years.
- While incidence rates for verotoxigenic *E. coli* infections are higher for the ON and BC sites than at the national level, a downward trend has been observed since 2006 at both the sentinel site and national levels.

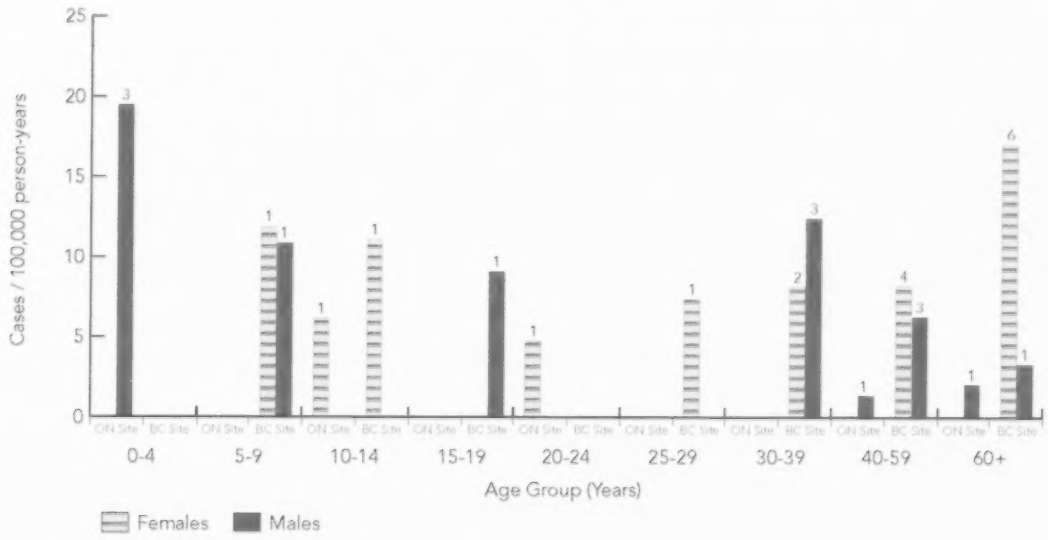
6. *YERSINIA*

6.1 Human Cases

In 2010 in the ON site, eight human cases of yersiniosis were reported, representing an incidence rate of 1.5 cases/100,000 person-years). Of these eight cases, one was travel-related (0.2 cases/100,000 person-years) and seven were classified as endemic (1.3 cases/100,000 person-years). Yersiniosis is not a nationally notifiable disease; therefore, the annual national and provincial incidence rates are not available for comparison. The incidence rate for endemic cases was highest among male children less than five years of age (Figure 6.1).

Between April and December 2010 in the BC site, 24 cases of *Yersinia* infection were reported, representing an incidence rate of 7.1 cases/100,000 person-years. All 24 cases were classified as endemic. The incidence rate was highest in females older than 60 years (Figure 6.1). The 2009 incidence rate for yersiniosis in all of British Columbia was 10.4 cases/100,000 person-years (***11***).

FIGURE 6.1. Incidence rates of human endemic yersiniosis in the ON and BC sites in 2010, by gender and age group.



NOTE: The number of cases is indicated above each bar.

6.2 Case Exposures

In the ON site, information on potential source exposures during the seven days prior to onset of illness was collected for six of the seven reported endemic cases of human yersiniosis (Appendix B.1). Given that there were less than 10 cases with exposure data, no exposure factors have been highlighted.

In the BC site, potential exposure information for the seven days prior to onset of illness was collected for 75% (18/24) of the reported endemic yersiniosis cases (Appendix B.2).

6.3 Surveillance of Potential Sources

Food

In June 2009, the method for recovering *Yersinia* from samples of retail pork was modified to increase test sensitivity, which resulted in a significant increase in the apparent prevalence of *Yersinia* among pork samples (3% in 2008 to 30% in 2009 and 82% in 2010).

Yersinia was isolated from 82% (86/105) of raw pork samples (Table 6.1). This increase in prevalence from 2009 was likely due to the method change that was implemented during the summer of 2009 to increase sensitivity. The higher prevalence of *Yersinia* contamination of retail pork chops coincides with higher amounts of these bacteria present in the contaminated pork. In 2010, 27% (23/86) of pork samples had *Yersinia* counts greater than 1,000 organisms/g (Appendix C). However, all *Yersinia* recovered from all 86 positive samples was non-pathogenic. By July 2010, testing for *Yersinia* on retail pork was discontinued because of the low (less than 1%) prevalence of strains pathogenic to humans since testing began in 2005.

Farm animals

Yersinia was isolated from 3% (4/120) of pooled swine fecal samples collected on 30 farms (Table 6.1). All isolates were pathogenic *Y. enterocolitica* serotypes (O:3 biotype 4).

Water

The proportion of Grand River surface water samples from which *Yersinia* was recovered was influenced by laboratory protocol changes. The changes started in 2008, when a different service laboratory was used. The culture method was then modified in 2009 to enhance its sensitivity, and a molecular pre-screening method was initiated that further increased culture sensitivity. However, in July of 2010, *Yersinia* testing was discontinued, largely because improvements to the method considerably increased the laboratory costs of *Yersinia* isolation from water samples yet a human-pathogenic strain had not been identified in five years of surveillance.

All *Y. enterocolitica* isolates from the untreated surface water samples were non-pathogenic.

6.4 Subtype Comparison

TABLE 6.1. Number (%) of *Yersinia* isolates detected and subtyped through integrated surveillance activities in the ON site in 2010, with human case information for the BC site provided for comparison.

METHOD	HUMAN		RETAIL	ON-FARM[a]	WATER[b]
	Endemic cases ON site	Endemic cases BC site	Pork chops	Swine	
Detection					
No. of samples tested	Unknown	Unknown	105	120	42
No. (%) of positive samples	7	24	86 (82%)	4 (3%) from 4 farms	32 (76%)
Subtyping					
No. of isolates subtyped	6	24	86	4	32[c]
Yersinia aleksici	0	0	0	0	1 (site B)
Pathogenic *Yersinia enterocolitica*[d]	6	20	0	4	0
Non-pathogenic *Y. enterocolitica*	0	0	50	0	12 (sites A,B,C,D)
Yersinia frederiksenii	0	1	14	0	3 (sites A,C,E)
Yersinia intermedia	0	0	18	0	14 (sites A,B,C,D)
Yersinia kristensenii	0	0	17	0	10 (sites A,B,C,D)
Yersinia mollaretti	0	2	0	0	1 (site D)
Yersinia pseudotuberculos	0	1	0	0	0

[a] Fecal samples were collected from 30 farms in the ON site for each type of food animal.

[b] Samples of untreated surface water were collected from five sites along the Grand River in the ON site: Canagagigue Creek (A), Conestogo River (B), Upper Grand River (C), Grand River, near drinking water intake (D), and Grand River, near a wastewater treatment plant effluent point (E).

[c] Multiple isolates were recovered from some samples, yielding 41 isolates in total.

[d] Of all subtypes listed, this particular subtype is the only pathogenic one.

6.5 Summary of *Yersinia* Results

- Findings from 2010 and from previous years show *Yersinia* continued to be a domestically acquired infection, as demonstrated by the low proportion of travel-related cases in the ON and BC sentinel sites.
- Pathogenic (serotype O:3) *Y. enterocolitica* was identified in pooled samples of swine feces from farms in the ON site.
- All *Yersinia* detected in untreated surface water samples and retail pork samples in the ON site were non-pathogenic.

7. LISTERIA

7.1 Human Cases

Human listeriosis is rare and is typically identified in immunocompromised individuals who develop severe disease requiring hospitalization. The annual national incidence rates for listeriosis in 2010 in all of Canada, Ontario, and British Columbia were 0.4 cases, 0.5 cases, and 0.3 cases/100,000 person-years respectively (4). One endemic case (male) was identified in 2010 in the ON site, and two endemic cases (both male) were detected between April and December 2010 in the BC site.

7.2 Surveillance of Potential Sources

Food

In 2010, active surveillance for *Listeria monocytogenes* in meat and produce was continuous. In the ON site, 2% (9/372) of bagged leafy green samples were found to be contaminated with the organism (Table 7.1). None of the 202 leafy green samples from the BC site were positive for *L. monocytogenes* in 2010.

Most raw meat samples from which *L. monocytogenes* was isolated contained amounts that were below the detection limit of the testing method used for bacterial quantification (9 of 15 [60%] pork isolates, 17 of 27 [63%] chicken isolates, and 12 of 23 [52%] beef isolates; Appendix C).

TABLE 7.1. *Listeria monocytogenes* detection data from integrated surveillance activities in the ON and BC sites in 2010.

RESULTS	HUMAN				RETAIL				
	Endemic ON site	Outbreak ON site	Endemic BC site	Outbreak BC site	Pork chops	Chicken breasts	Ground beef	Leafy greens ON site	Leafy greens BC site
No. of samples tested	Unknown	Unknown	Unknown	Unknown	196	197	197	372	202
No. positive	1	0	2	0	15	27	23	9	0
Percentage positive	NC	NC	NC	NC	8%	14%	12%	2%	0%

NC = Not calculated

7.3 Subtype Comparison

Listeria monocytogenes 1/2a, 1/2b, and 1/2c were the three most common serotypes in the retail food sources tested and are reported to be the predominant serotypes in Canada causing human illness (12). No serotyping was conducted on isolates from the human cases in either sentinel site. Of the top three human serotypes reported by Clark et al. (2010), 1/2a and 1/2b were detected on all retail meat products and bagged leafy greens; 1/2c was detected on all retail meat products (Table 7.2).

When pulsed-field gel electrophoresis (PFGE) patterns from human clinical specimens and retail meat and produce samples were compared, no predominant subtype emerged across the sources, however pattern LMAAI.0126 was found in all three retail meat commodities (Table 7.3). The one human case identified in 2010 had PFGE pattern LMAAI.0423, which has historically been detected in samples of retail pork and beef cattle feces in the ON site.

PulseNet Canada provides information on the most common human PFGE patterns detected at a national level, and these patterns were compared with those detected in the FoodNet Canada sentinel sites in 2010. The two most common PFGE patterns reported from across Canada to PulseNet Canada in 2010 were LMAAI.0234 and LMAAI.0001. However, none of the *L. monocytogenes* isolates associated with cases of human listeriosis in the ON site that were subtyped had these PFGE patterns. The remaining PFGE patterns identified in the ON site in 2010, as well as historical PFGE pattern data, can be found in Appendix D.

TABLE 7.2. Integrated comparison of the number of various serotypes of *Listeria monocytogenes* identified through surveillance activities in the ON site in 2010 versus in 2005 through 2009.

SEROTYPE	HUMAN		RETAIL				NON-HUMAN TOTAL 2010
	Endemic ON site	Outbreak ON site	Pork chops	Chicken breasts	Ground beef	Leafy greens ON site	
No. serotyped	0 (3)	0 (3)	14 (59)	27 (178)	22 (127)	9 (0)	72
1/2a	0 (2)	0 (3)	7 (23)	17 (119)	13 (55)	5 (0)	42
1/2b	0 (0)	0 (0)	4 (17)	7 (33)	6 (66)	1 (0)	18
1/2c	0 (0)	0 (0)	3 (17)	3 (9)	1 (5)	0 (0)	7
3a	0 (0)	0 (0)	0 (1)	0 (2)	0 (1)	0 (0)	0
3b	0 (0)	0 (0)	0 (0)	0 (6)	0 (0)	0 (0)	0
4a	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
4b	0 (1)	0 (0)	0 (1)	0 (8)	2 (0)	3 (0)	5

Data in parentheses are the sum of all isolates obtained from 2005–2009.

TABLE 7.3. Integrated comparison of the number of various pulsed-field gel electrophoresis patterns among *Listeria monocytogenes* isolates identified through surveillance activities in the ON site in 2010 versus in 2005 through 2009.

PATTERN	HUMAN	RETAIL				ON-FARM				NON-HUMAN TOTAL	HUMAN TOP 5 RANKING*
	Endemic cases ON site	Pork chops	Chicken breasts	Ground beef	Leafy greens ON site	Swine	Broiler chickens	Beef cattle	Dairy cattle		
No. subtyped	1 (3)	14 (59)	27 (178)	22 (127)	9 (3)	0 (4)	0 (8)	0 (74)	0 (15)	—	—
LMAAI.0001	0 (0)	0 (3)	2 (17)	0 (6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (26)	2
LMAAI.0003	0 (1)	0 (1)	0 (1)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (3)	5
LMAAI.0093	0 (1)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (1)	0 (11)	0 (0)	0 (13)	—
LMAAI.0126	0 (0)	1 (2)	1 (4)	1 (5)	0 (0)	0 (0)	0 (0)	0 (5)	0 (0)	3 (16)	4
LMAAI.0204	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (9)	0 (5)	1 (14)	4
LMAAI.0234	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	1
LMAAI.0265	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	—
LMAAI.0423	1 (0)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (2)	—
LMAAI.0857	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4

— = Not applicable.

* Represents PulseNet Canada ranking of the most common patterns identified nationally in 2010.

NOTE: Two human cases of listeriosis were reported in the BC site in 2010, but none of the associated isolates were subtyped.

7.4 Summary of *Listeria monocytogenes* Results

- As in previous years, pathogenic strains of *Listeria monocytogenes* were recovered from samples of retail skinless chicken breasts, pork chops, and ground beef. Additionally, in 2010, pathogenic strains were isolated from bagged leafy greens.
- The scientific literature suggests that abattoirs and meat processing environments rather than farm animals may be an important source of *L. monocytogenes* (*13*). Although testing of farms for the pathogen was discontinued in 2008, the retail meat data from many historical surveillance years indicate that pathogenic serotypes of *L. monocytogenes* are present on raw chicken, beef, and pork meat sold at retail, as well as in bagged leafy greens.
- The isolate recovered from the single human endemic case of listeriosis in the ON site in 2010 was subtyped by PFGE analysis. This isolate had the PFGE pattern LMAAI.0423, which has historically been isolated from retail pork and from beef cattle feces.

8. *SHIGELLA*

8.1 Human Cases

In 2010 in the ON site, six human cases of shigellosis were reported, representing an incidence rate of 1.1 cases/100,000 person-years. Of these cases, five (0.9 cases/100,000 person-years) were travel-related and one (0.18 cases/100,000 person-years) was classified as endemic.

Between April and December 2010 in the BC site, six cases of shigellosis were reported, representing an incidence rate of 1.8 cases/100,000 person-years. Of these, two (0.6 cases/100,000 person-years) were travel-related and four (1.2 cases/100,000 person-years) were classified as endemic.

In comparison, the annual incidence rates for human shigellosis in 2010 in all of Canada, Ontario, and British Columbia were 2.7, 1.9, and 4.2 cases/100,000 person-years, respectively (**4**).

8.2 Surveillance of Potential Sources

In 2010, *Shigella* testing of bagged leafy greens was only performed from January to March, and only in the ON site. Of 98 samples tested, no *Shigella* was identified.

9. PARASITES

9.1 *Giardia*

9.1.1 Human Cases

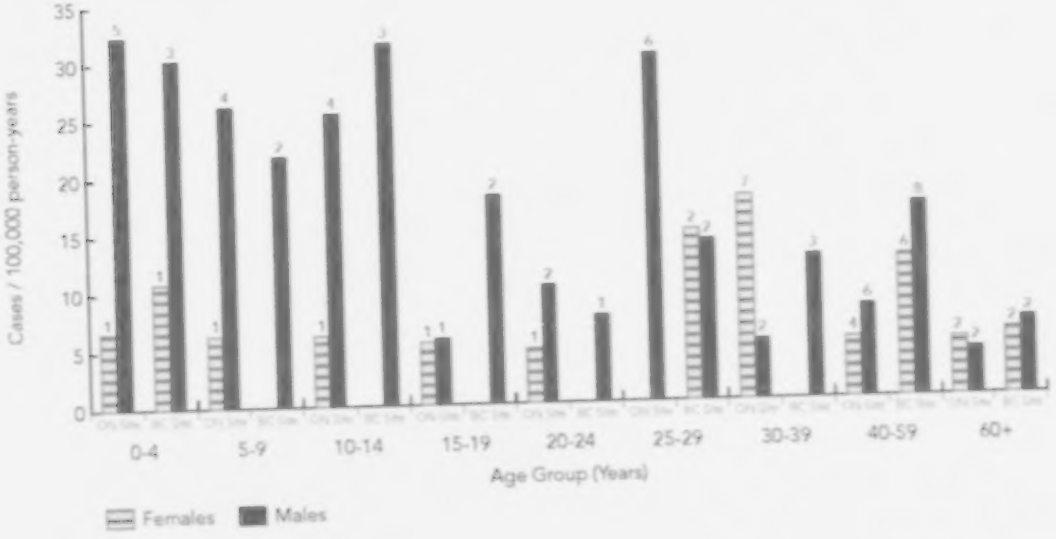
In the ON site in 2010, 78 human cases of giardiasis were reported, representing an incidence rate of 14.8 cases/100,000 person-years. Of these cases, 28 (36%) were travel-related (5.3 cases/100,000 person-years) and 50 (64%) were classified as endemic (9.5 cases/100,000 person-years). There were no outbreak-related cases in the ON site.

In the BC site between April and December 2010, 45 human cases of giardiasis were reported, for an incidence rate of 13.3 cases/100,000 person-years). Of these, 8 (18%) were travel-related (2.4 cases/100,000 person-years) and 37 (82%) were classified as endemic (10.9 cases/100,000 person-years). There were no outbreak-related cases in the BC site.

In comparison, the 2010 annual incidence rates for human giardiasis in all of Canada, Ontario, and British Columbia were 11.5, 10.5, and 13.7 cases/100,000 person-years, respectively (4).

Of the endemic cases in the ON site, 18 (6.8 cases/100,000 person-years) were female and 32 (12.1 cases/100,000 person-years) were male (Figure 9.1). Of the endemic cases in the BC site, 11 (6.4 cases/100,000 person-years) were female and 26 (15.4 cases/100,000 person-years) were male.

FIGURE 9.1. Incidence rates of human endemic giardiasis in the ON and BC sites in 2010, by gender and age group.



NOTE: The number of cases is indicated above each bar.

9.1.2 Case Exposures

Potential exposure information for the 25 days prior to the onset of illness was available for 44 of the 50 (88%) endemic giardiasis cases in the ON site and for 22 of 37 (59%) cases in the BC site (Appendix B). In the BC site, a higher proportion of giardiasis cases than other reported enteric disease cases had a history of swimming in a lake, pool, or river.

9.1.3 Surveillance of Potential Sources

FOOD

In 2010, of the 372 bagged leafy green samples collected in the ON site, *Giardia* contamination was confirmed by molecular methods in 11 (3%). These positive samples were then tested by microscopy, which led to the identification of four positive samples. No further subtyping was performed.

FARM ANIMALS

Testing of fecal samples collected from farm animals for the presence of *Giardia* stopped in 2009 (Table 9.1).

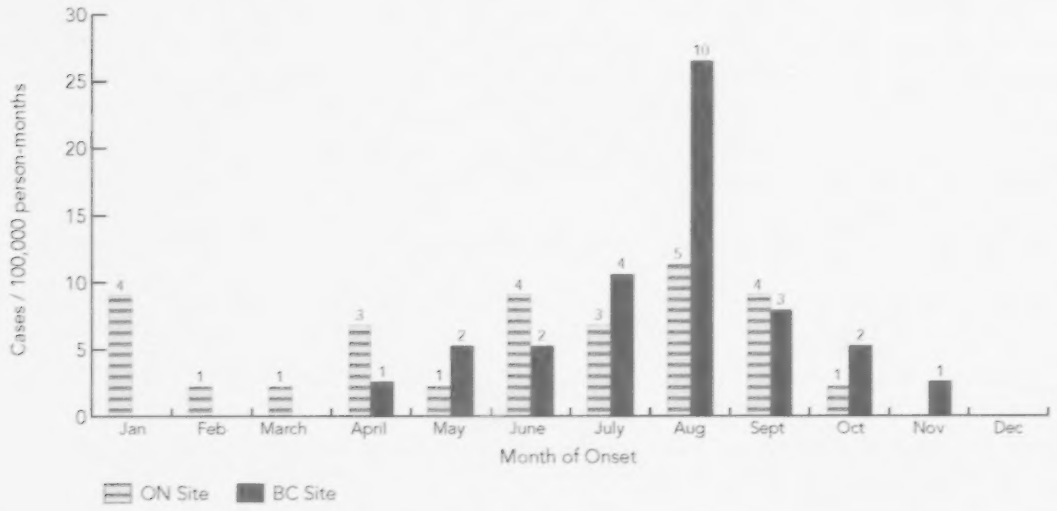
WATER

Twelve collected samples of untreated surface water, all of which originated just upstream of the drinking water treatment plant intake (site D), were found to contain *Giardia* (Table 9.1). Further molecular subtyping was not performed. Mean concentrations of *Giardia* cysts were highest in March, and between July and August.

9.1.4 Temporal Distribution

The monthly number of reported cases varied from one to ten, with the highest number in August for both sentinel sites. This pattern is similar to the expected late summer/early fall peak observed with giardiasis (Figure 9.2).

FIGURE 9.2. Distribution of human endemic cases of giardiasis in the ON and BC sites in 2010, by month.



NOTE: The number of cases is indicated above each bar.

9.1.5 Subtype Comparison

TABLE 9.1. *Giardia* detection and subtyping data from surveillance activities in the ON site in various years.

METHOD	ON-FARM[a]				WATER[b]
	Swine	Broiler chickens	Beef cattle	Dairy cattle	
Years covered	2005–2006	2007–2008	2007–2008	2005–2006	2010 (2009)
Microscopy					
No. of samples tested	122	126	112	179	12 (10)
No. of positive samples	62	0	72	72	12 – site D (10)
Percentage of samples positive	51%	0%	64%	40%	100% (100%)
Polymerase chain reaction (PCR) assay					
No. of samples tested	122	126	112	179	0 (0)
No. (%) of positive samples	80 (66%)	12 (10%)	77 (69%)	54 (30%)	0 (0%)
DNA sequencing					
No. of samples with results	63	7	73	43	0 (4)
Assemblage A	0	1	0	3	0 (0)
Assemblage B	58	4	0	18	0 (0)
Assemblage E	5	2	73	22	0 (0)
Giardia microti	0	0	0	0	0 (3 – site D)

[a] Fecal samples were collected from 30 farms in the ON site for each type of food animal.

[b] Samples of untreated surface water were collected from five sites along the Grand River in the ON site: Canagagigue Creek (A), Conestogo River (B), Upper Grand River (C), Grand River, near drinking water intake (D), and Grand River, near a wastewater treatment plant effluent point (E).

9.2 *Cryptosporidium*

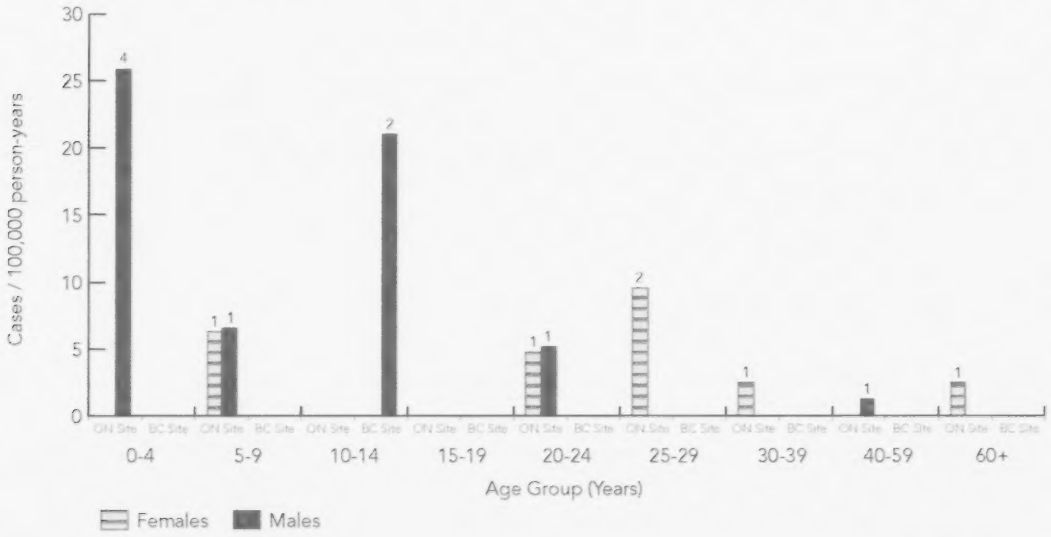
9.2.1 Human Cases

In 2010, the ON site had 23 reported human cases of cryptosporidiosis (4.4 cases/100,000 person-years). Of these 23, 10 (1.9 cases/100,000 person-years) were travel-related and 13 (2.5 cases/100,000 person-years) were classified as endemic (Figure 9.3).

Between April and December 2010, the BC site had a total of five reported cases of cryptosporidiosis (1.5 cases/100,000 person-years). Of these, three (0.9 cases/100,000 person-years) were travel-related and two (0.6 cases/100,000 person-years) were classified as endemic (Figure 9.3).

In comparison, the 2010 annual incidence rates for cryptosporidiosis in all of Canada, Ontario, and British Columbia were 1.9, 2.5, and 1.2 cases/100,000 person-years, respectively (4). Of the endemic cases in the ON site, six (2.3 cases/100,000 person-years) were female and seven (2.6 cases/100,000 person-years) were male. Of the endemic cases in the BC site, both cases involved males.

FIGURE 9.3. Incidence rates of human endemic cryptosporidiosis in the ON and BC sites in 2010, by gender and age group.



NOTE: The number of cases is indicated above each bar.

9.2.2 Case Exposures

Information for potential source exposures during the 12 days prior to the onset of illness was available for 8 of the 13 endemic cryptosporidiosis cases in the ON site and for both cases in the BC site (Appendix B). Given that there were less than ten cases with exposure data in each of the sites, no exposure factors have been highlighted.

9.2.3 Surveillance of Potential Sources

FOOD

In 2010, no *Cryptosporidium* was detected via molecular methods in any of the 372 samples of bagged leafy greens collected in the ON site. Of the 202 samples of bagged leafy greens collected in the BC site, none were found to contain *Cryptosporidium*.

FARM ANIMALS

Analysis of farm animal fecal samples for *Cryptosporidium* was stopped in 2009 (Table 9.2).

WATER

Fewer untreated surface water samples were tested for *Cryptosporidium* in 2010 than in previous years, and those that were obtained were restricted to monthly collection at a point upstream of the drinking water treatment plant intake on the Grand River. *Cryptosporidium* was detected in 11 of 12 samples (Table 9.2). In 2010, *C. andersoni* once again dominated as the most common genotype. It should be noted that *C. andersoni*, although not commonly associated with human infections, has been implicated in some cases of cryptosporidiosis in immunocompetent individuals (***14***, ***15***), suggesting that it might indeed be mildly infectious. *Cryptosporidium hominis* (a human-pathogenic strain) was detected in one of the nine samples that underwent DNA sequencing.

TABLE 9.2. *Cryptosporidium* detection and subtyping data for integrated surveillance activities in the ON and BC sites in various years.

METHOD	RETAIL		ON-FARM[a]				WATER[b]
	Leafy greens ON site	Leafy greens BC site	Swine	Broiler chickens	Beef cattle	Dairy	
Years covered	2010 (2009)	2010 (2009)	2005–2006	2007–2008	2007–2008	2005–2006	2010
Microscopy							
No. of samples tested	0 (32)	0 (0)	122	126	112	179	12
No. of positive samples	0 (23)	0 (0)	54	0	27	14	11 – site D
Percentage of samples positive	0% (72%)	0% (0%)	44%	0 %	24%	8%	92%
Polymerase chain reaction assay							
No. of samples tested	372 (376)	202 (0)	122	126	112	179	0 (0)
No. of positive samples	0 (32)	0 (0)	68	13	31	40	0 (0)
Percentage of samples positive	0% (9%)	0% (0%)	56%	10%	28%	22%	0% (0%)
DNA sequencing							
No. of isolates sequenced[f]	0 (28)	0 (0)	53	7	28	23	9
Cryptosporidium andersoni[c]	0 (0)	0 (0)	0	0	0	0	5
Cryptosporidium baileyi chicken genotype (CB01)	0 (0)	0 (0)	0	0	0	0	0
Cryptosporidium bovis	0 (0)	0 (0)	0	0	0	0	0
Cryptosporidium muris	0 (0)	0 (0)	3	1	0	0	0
Cryptosporidium hominis[c,d]	0 (0)	0 (0)	0	0	0	0	1
Cryptosporidium muskrat genotype	0 (0)	0 (0)	0	0	0	0	1
Cryptosporidium parvum (bovine genotype)[c]	0 (28)	0 (0)	31	6	1	11	0
Cryptosporidium ryanae[c]	0 (0)	0 (0)	0	0	0	2	0
Cryptosporidium suis[c]	0 (0)	0 (0)	1	0	0	0	0
Cryptosporidium goose genotype II	0 (0)	0 (0)	0	0	0	0	1
Cryptosporidium skunk genotype	0 (0)	0 (0)	0	0	0	0	3
Cryptosporidium deer mouse III genotype	0 (0)	0 (0)	0	0	0	0	1
Cryptosporidium pig genotype II[c]	0 (0)	0 (0)	20	0	0	0	0
Cryptospodium ubiquitum[e]	0 (0)	0 (0)	0	0	0	0	2
Cryptosporidium vole genotype	0 (0)	0 (0)	0	0	0	0	1
Other	0 (0)	0 (0)	0	0	0	0	2

[a] Fecal samples were collected from 30 farms in the ON site for each type of food animal.

[b] Samples of untreated surface water were collected from five sites along the Grand River in the ON site: Canagagigue Creek (A), Conestogo River (B), Upper Grand River (C), Grand River, near drinking water intake (D), and Grand River, near a wastewater treatment plant effluent point (E).

[c] Known to be pathogenic to humans.

[d] Only found in humans.

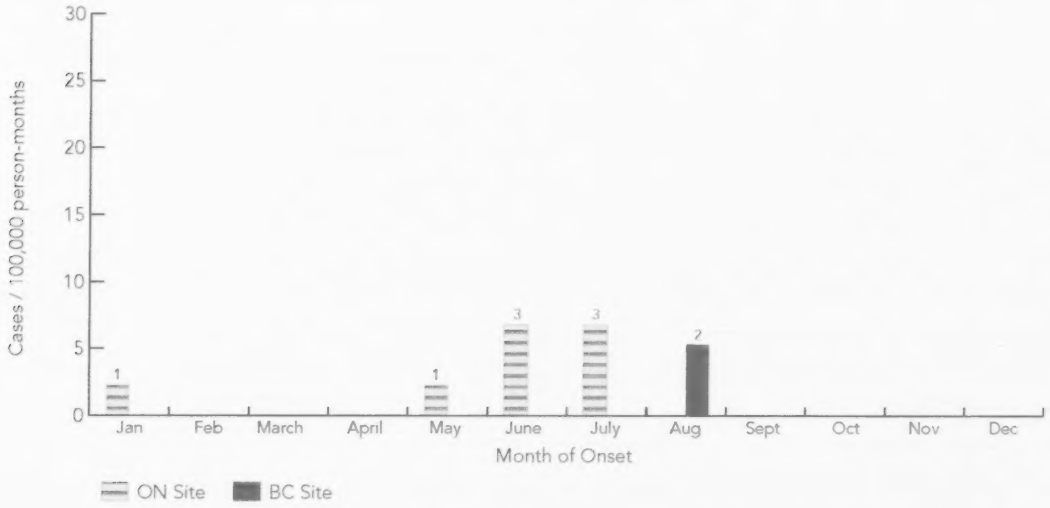
[e] Previously named *Cryptosporidium cervine*.

[f] Not all positive samples were sequenced. However, some samples have more than one sequencing result; consequently, the column total may exceed the total number sequenced.

9.2.4 Temporal Distribution

Endemic cases of cryptosporidiosis occurred mostly in the summer months, with one case reported in February (Figure 9.4).

FIGURE 9.4. Distribution of human endemic cryptosporidiosis cases in the ON and BC sites in 2010, by month.



NOTE: The number of cases is indicated above each bar.

9.3 *Cyclospora*

One travel-related human case of cyclosporiasis was reported in the ON site during 2010, representing an incidence rate of 0.2 cases/100,000 person-years. Three travel-related cases were reported in the BC site between April and December 2010, for an incidence rate of 0.9 cases/100,000 person-years.

Cyclosporiasis is not considered to be endemic to Canada. Therefore, active surveillance for *Cyclospora* was not performed for the on-farm and water surveillance components of the FoodNet Canada program. However, imported (as well as domestic) bagged leafy greens were tested for the parasite. Initial pre-screening by molecular methods identified no *C. cayetanensis* in any samples in the ON and BC sites.

TABLE 9.3. *Cyclospora* detection and subtyping data for samples of retail bagged leafy greens in the ON and BC sites in 2010.

METHOD	ON SITE	BC SITE
Microscopy		
No. of samples tested	0	0
No. of positive samples	0	0
Percentage of samples positive	0%	0%
Polymerase chain reaction (PCR) assay		
No. of samples tested	372	202
No. of positive samples	0	0
Percentage of samples positive	0%	0%
DNA sequencing		
No. of samples sequenced	0	0

9.4 *Entamoeba*

In 2010 in the ON site, 26 human cases of amoebiasis were reported, representing an incidence rate of 4.9 cases/100,000 person-years. Of these 26 cases, 14 (2.7 cases/100,000 person-years) were travel-related and 12 (2.3 cases/100,000 person-years) were classified as endemic. Of the endemic cases, one (0.4 cases/100,000 person-years) was female and 11 (4.2 cases/100,000 person-years) were male.

No data are available for the BC site because human cases of amoebiasis are not reported to FoodNet Canada since the laboratory does not distinguish between the pathogenic and non-pathogenic types.

Amoebiasis was removed from the Canadian Notifiable Disease Surveillance System as of January 2000 (*16*); therefore, comparative incidence data cannot be provided for Canada.

In the ON site, potential exposure information for the seven days prior to the onset of illness was available for 10 of the 12 cases of amoebiasis (Appendix B.1).

Entamoeba is a human intestinal pathogen. Although not considered a zoonotic agent, *Entamoeba* has been known to infect dogs (*17*). No efforts were made to identify the organism in the various exposure sources (food, farm animals, and water) in the ON and BC sites.

9.5 Integrated Overview

- In the ON site, both *Giardia* and *Cryptosporidium* appear to be endemic in untreated surface water from the Grand River.
- *Cryptosporidium hominis*, which infects only humans, was detected in untreated surface water. *Cryptosporidium andersoni*, although rarely implicated in human cryptosporidiosis, was also found in untreated surface water, consistent with findings in previous surveillance years.

10. EPISODIC STUDIES

While continuous surveillance in the sentinel sites provides the core data for FoodNet Canada's analyses and reporting activities, episodic surveillance activities are conducted to inform specific hypotheses or research questions in order to complement results obtained from the continuous activities. The FoodNet Canada infrastructure provides an excellent platform that can be used for these studies.

Episodic Study: Testing for bacteria, viruses, and parasites in bagged leafy greens

In 2010, sample collection for ready-to-eat bagged leafy greens continued in the ON site throughout the year (372 samples) but most bacterial testing was discontinued in March because of low yields (Table 10.1). In the BC site, sample collection was initiated in April 2010 (202 samples).

TABLE 10.1. Number (%) of retail leafy greens samples in which selected bacteria were detected via bacterial culture and polymerase chain reaction (PCR) assay in the ON and BC sites in 2010.

BACTERIA	ON SITE (N = 372)		BC SITE (N = 202)	
	Culture	PCR	Culture	PCR
Campylobacter	0 (0%)[a]	NT	NT	NT
Salmonella	0 (0%)[b]	NT	NT	NT
VTEC	NT	0 (0%)[a]	NT	NT
Generic *Escherichia coli*	2 (1%)[c]	NT	NT	NT
Listeria monocytogenes	9 (2%)	NT	0 (0%)	NT
Shigella	NT	0 (0%)[a]	NT	NT

NT = Not tested

VTEC = Verotoxigenic *Escherichia coli*.

[a] 98 samples tested.

[b] 168 samples tested.

[c] 140 samples tested.

In the ON site, *Listeria monocytogenes* was detected in nine samples of bagged leafy greens via bacterial culture. Four of the nine positive samples had an identical pulsed-field gel electrophoresis (PFGE) pattern (LMAAI.0096) and serotype (1/2 a; Table 7.3). This pattern was also found in two bagged leafy green samples from the ON site in 2009. The PFGE pattern LMAAI.0096 has not been detected through any of the other FoodNet Canada components nor in human listeriosis cases reported to PulseNet Canada in 2010. Generic *Escherichia coli* was detected in two samples (1.3 and 1.9 log colony-forming units/g of sample). In the BC site, *L. monocytogenes* was the only bacteria for which testing was performed, and none of the leafy green samples yielded any positive results.

The recovery rates for parasites and viruses were similar between the two sentinel sites. *Giardia* was detected by polymerase chain reaction (PCR) in 11 leafy green samples in the ON site, of which four were confirmed to be contaminated with *Giardia* via microscopy. In the BC site, *Giardia* was detected by PCR in four samples and confirmed via microscopy in one of the four. Genotyping revealed that all *Giardia* were Assemblage B, which can be pathogenic to humans. Neither *Cryptosporidium* nor *Cyclospora* were detected in leafy green samples.

Norovirus was detected by PCR in two leafy green samples in the ON site and in one sample in the BC site (Table 10.2). Genotype sequencing results indicated all samples from both sites belonged to genogroup I (GI). This strain is a known human pathogen. None of the samples of bagged leafy greens from either sentinel site were positive for rotavirus in 2010.

TABLE 10.2. Number (%) of retail leafy greens samples in which selected parasites and viruses were detected via polymerase chain reaction (PCR) assay and microscopy in the ON and BC sites in 2010.

	ON SITE (N = 372)		BC SITE (N = 202)	
PATHOGEN	PCR	Microscopy*	PCR	Microscopy*
Cryptosporidium	0 (0%)	wNT	0 (0%)	NT
Giardia	11 (3%)	11 (4)	4 (2%)	4 (1)
Cyclospora	0 (0%)	NT	0 (0%)	NT
Norovirus	2 (0.5%)	NT	1 (0.5%)	NT
Rotavirus	0 (0%)	NT	0 (0%)	NT

NT = Not tested

*Number tested (number positive)

TABLE 10.3. Results of norovirus detection in samples of retail bagged leafy greens in the ON and BC sites in 2010.

METHOD	ON SITE	BC SITE
PCR assay		
No. of samples tested	372	202
No. of positive samples	2	1
Percentage of samples positive	0.54%	0.50%
Genotyping		
No. of samples with sequencing results	2	1
GI.13	2	1

Data were collected regarding the country of origin of the bagged leafy greens when indicated on the product packaging. The majority of samples collected in the ON site (90%; 335/372) and the BC site (98%; 198/202) originated from the United States (Table 10.4).

Although Norovirus and *Giardia* were detected on pre-washed bagged lettuce, their viability is unknown. Conversely, viable *L. monocytogenes* was cultured on pre-washed bagged lettuce. However, there were no reported illnesses linked to these findings. It is important to note that *Listeria* does occur naturally in the environment, and can be found in soil, plants and vegetables. Also, the majority of the pre-washed bagged lettuce samples represent imported products. In Canada overall, the majority of leafy greens are imported (*18*). This finding however, does require further investigation. Consuming vegetables remains part of a balanced, healthy diet.

TABLE 10.4. Country of origin of bagged leafy greens collected in the ON and BC sites in 2010.

COUNTRY	ON SITE	BC SITE	TOTAL
United States	335[a]	198[b]	533
Canada	17[c]	1	18
Mexico	8[d]	0	8
United States and Canada	8[e]	0	8
United States and Mexico	3	1	4
Unknown	1	2	3
Grand total	**372**	**202**	**574**

Number of positive samples:

[a] 2 generic *E. coli*, 7 *Listeria monocytogenes*, 9 *Giardia* spp., 1 Norovirus

[b] 4 *Giardia* spp., 1 Norovirus

[c] 2 *Listeria monocytogenes*, 1 *Giardia* spp.

[d] 1 Norovirus

[e] 1 *Giardia* spp.

11. TEMPORAL VARIATIONS

Identification of seasonal and temporal trends is a key objective of health surveillance efforts. Knowledge of historical trends allows the current data to be assessed in context. To this end, statistical modeling can be used to assess the significance of year-to-year or season-to-season differences, and the results can aid in the forecasting of temporal or seasonal peaks. For some diseases, such modeling allows for effective timing of vaccine production and distribution (e.g. influenza vaccines) and public education strategies (e.g. waterborne diseases associated with recreational water use in the summer).

11.1 Temporal Variations in Enteric Disease Incidence

Annual and seasonal variation models

In the current FoodNet Canada design, cases of human enteric disease are aggregated to monthly counts from the ON site and are classified as travel- or non-travel-related. Because travel- and non-travel related cases are expected to differ in their temporal patterns and exposure sources, temporal analyses for this report were limited to the non-travel-related cases from June 2005, when FoodNet Canada activities began, through December 2010.

To assess the statistical significance of any seasonal or yearly variation in numbers of reported cases, Poisson or negative binomial (when over-dispersion existed) regression models were built to evaluate the effect of year, season, and the interaction between the two as predictors of enteric disease. Given that the population of the ON site increased in size over the surveillance period, the natural logarithm of the population size was included in all models as the offset value. Seasons were defined as follows: winter = December through February; spring = March through May; summer = June through August; and fall = September through November. Predicted values for the models with significant independent variables were plotted with the raw counts in Figure 11.1.

Model results

Neither year nor season was a significant predictor for amoebiasis, cryptosporidiosis, or yersiniosis. These illnesses were reported rarely, with less than six cases per month over the time frame, and consequently did not provide enough data to detect any trends. However, raw counts suggested that cryptosporidiosis is more common in August and September than in other months. Interactions between season and year were not significant in any model.

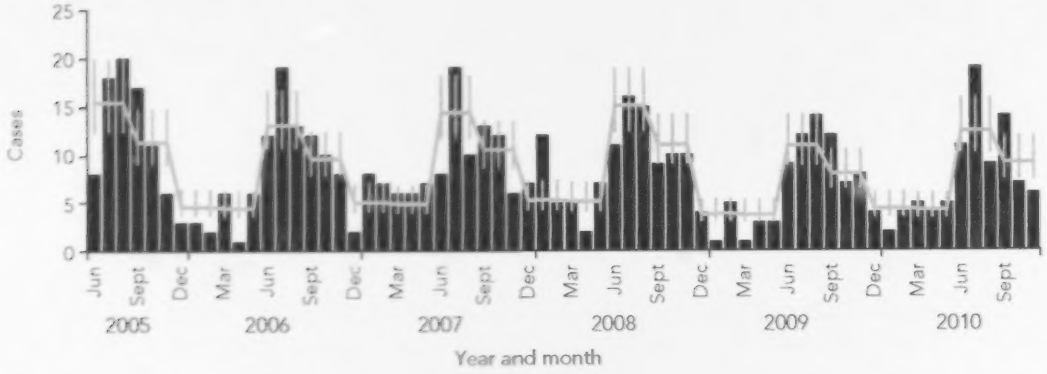
The number of cases of campylobacteriosis varied significantly by year and season, and peaks were most likely to have occurred during the summer months. A slight variation in the burden of illness was observed from year to year, however there was no consistent trend over the surveillance period (Figure 11.1).

In the verotoxigenic *Escherichia coli* (VTEC) infection model, year was a significant predictor, with the number of cases declining slightly over time.

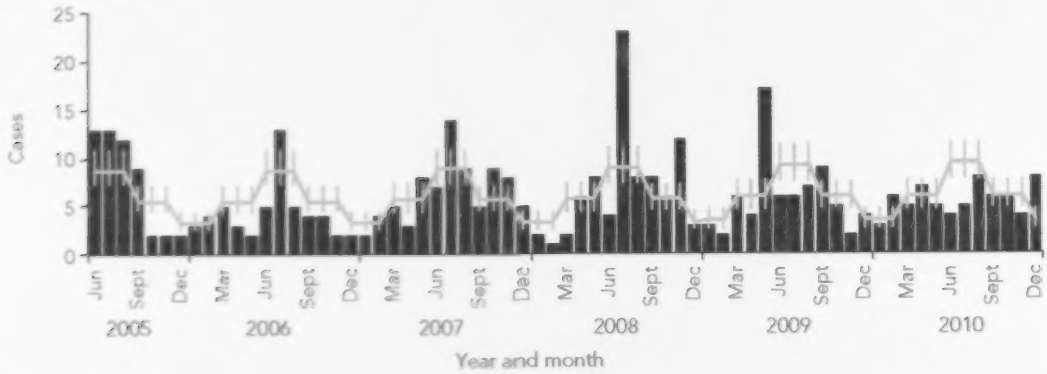
Season was a significant predictor in the giardiasis and salmonellosis models, but not year. Both illnesses had peaks in the summer months, and their yearly baseline incidence remained constant over time (Figure 11.1).

FIGURE 11.1. Raw monthly counts (based on onset dates; black bars) and predicted counts with confidence limits (grey lines) of sporadic, non-travel-related cases of selected enteric diseases reported in the ON site from June 2005 through December 2010.

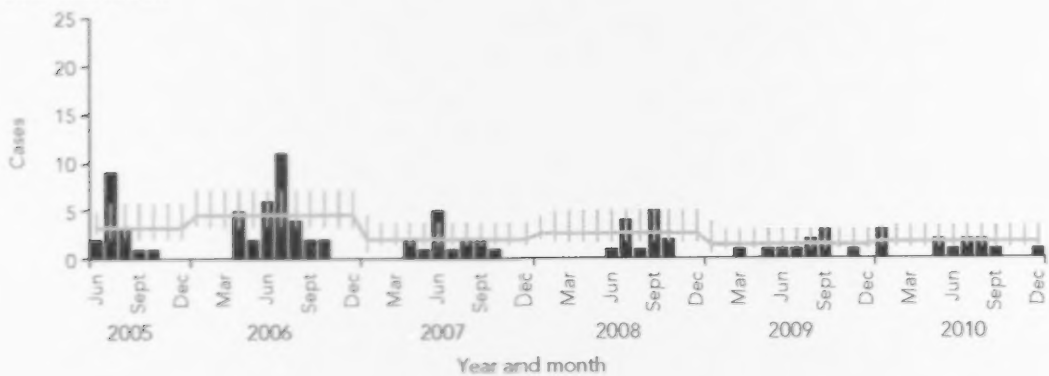
Campylobacteriosis

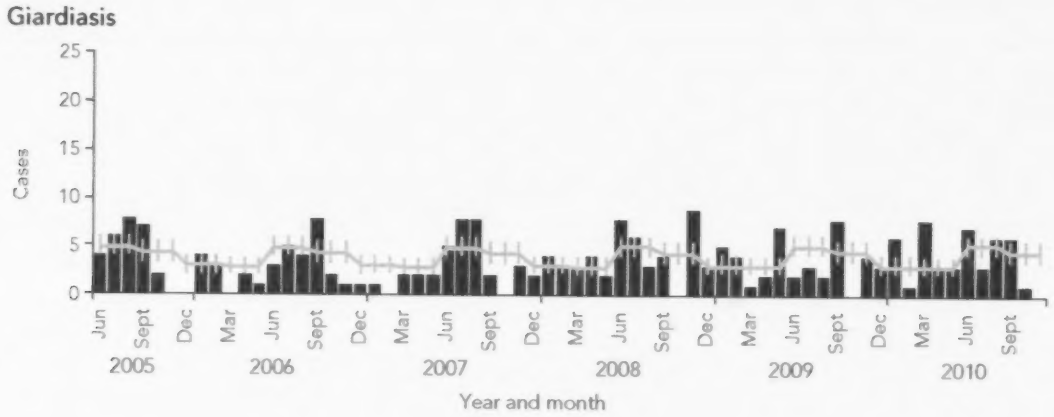


Salmonellosis



VTEC Infection



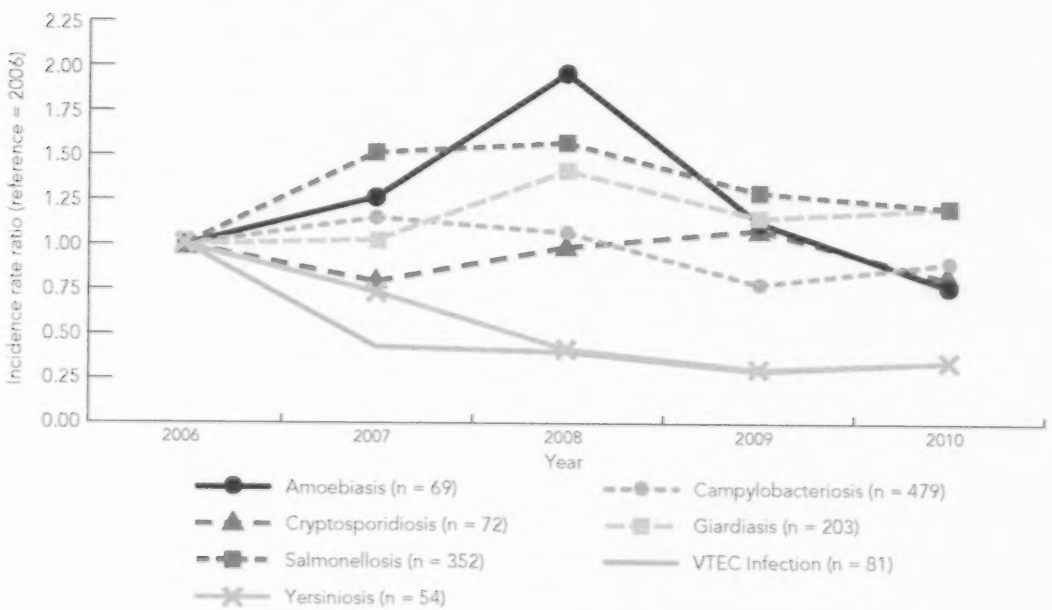


Changes in the incidence rate over time

Another option for visualizing the change in incidence of enteric illness over time is to plot the relative incidence rates (Figure 11.2). This method allows one to compare the incidence in any given year to that in a chosen baseline year. The baseline chosen for the 2010 model was the first full year of surveillance in the ON site (2006). Any value greater than one indicates that the incidence in the year in question was greater than the baseline incidence in 2006, whereas any value less than one indicates that the incidence was less than that of 2006.

Results of note include a decreasing incidence of yersiniosis and VTEC infection over the 2006 to 2010 period, and a peak in the incidence rate ratio for amoebiasis in 2008.

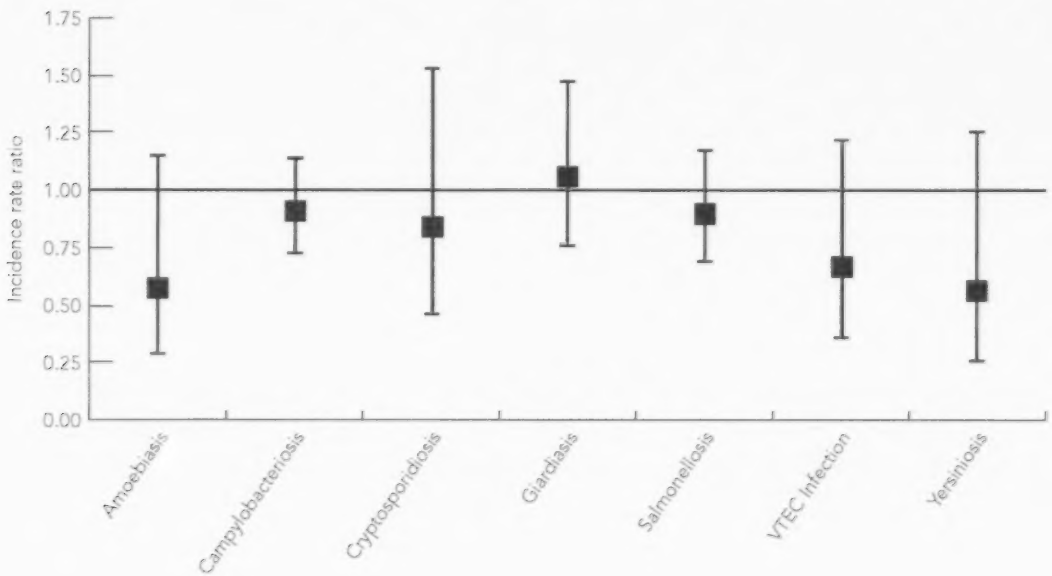
FIGURE 11.2. Temporal changes in incidence rates of reportable enteric diseases in the ON site, relative to incidence rates in 2006.



VTEC = Verotoxigenic *Escherichia coli*

Because any given year may be an anomaly within the temporal pattern, use of a single year as the baseline year in calculations of incidence rate ratio may not provide a full picture of the disease patterns. All historical data were consequently used to develop a new baseline for comparison with the rates reported in 2010. This new baseline was developed by summing the total number of cases reported from 2006 to 2009 for each illness and dividing by the population-years at risk contributed by individuals living in the ON site area over the time frame. Incidence rate ratios and associated 95% confidence intervals were then calculated for 2010 compared with this historical baseline (Figure 11.3). These analyses revealed no statistically significant differences between the 2010 incidence rates and those reported historically, as the 95% confidence limits for each incidence rate ratio included (crossed) the null value of one.

FIGURE 11.3. Incidence rate ratios and 95% confidence intervals for various enteric diseases, comparing the rate for 2010 with the mean annual rate for the period 2006 through 2009.



VTEC = Verotoxigenic *Escherichia coli*

11.2 Temporal Variations in Potential Sources

11.2.1 Farm Animals

Multivariable logistic regression models were used to estimate the probability of isolation of *Campylobacter*, *Yersinia*, *Salmonella*, and *E. coli* O157:H7 from fecal samples collected from swine, dairy cattle, beef cattle, and broiler chicken farms. Year and season were assessed as predictors, as well as the potential interaction between year and season.

SWINE

No significant effect was identified of season or year on the probability of *E. coli* O157:H7 or *Salmonella* isolation from swine feces. Year and season were not significant predictors in the models developed because of the stability in the proportion of positive isolates over time; *Salmonella* was isolated from approximately 30% of samples per year and *E. coli* was recovered from less than 6%. In contrast, season, year, and the interaction between season and year were significant predictors for *Campylobacter* isolation; a high proportion of samples were positive for *Campylobacter* in 2005, followed by a decline in 2006 and 2007, and an incline again to a high prevalence from 2008 through 2010. The increase in 2008 is known to reflect a change in laboratory isolation methods at the time, and therefore, does not reflect a true increase in the on-farm prevalence. Season and year were significant predictors of *Yersinia* isolation. Although the probability of *Yersinia* isolation was consistently low, the model suggested peaking in the spring season, with the baseline prevalence varying slightly by year (Figure 11.4).

BROILER CHICKENS

Neither season nor year had a significant effect on the probability of *Campylobacter* or *E. coli* O157:H7 isolation from broiler chicken feces, regardless of the laboratory methods change for *Campylobacter* isolation. Both of these pathogens were isolated from less than 6% of samples each year from 2007 to 2010. In contrast, both season and year were significant predictors of *Salmonella* isolation, with a higher probability of isolation in the fall and winter, compared with in the spring and summer (Figure 11.4). An interesting decrease in the probability of *Salmonella* isolation was evident during 2009; however, that probability increased subsequently, returning to pre-2009 values in 2010.

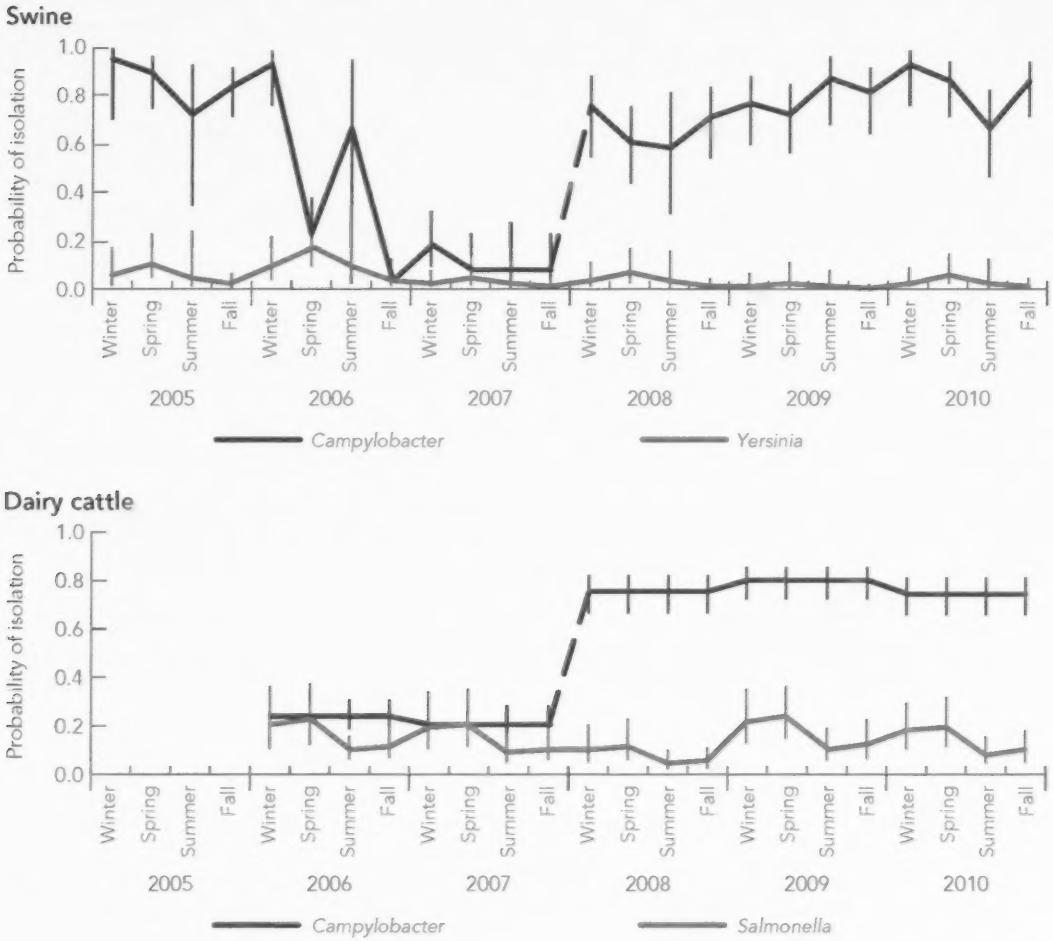
DAIRY CATTLE

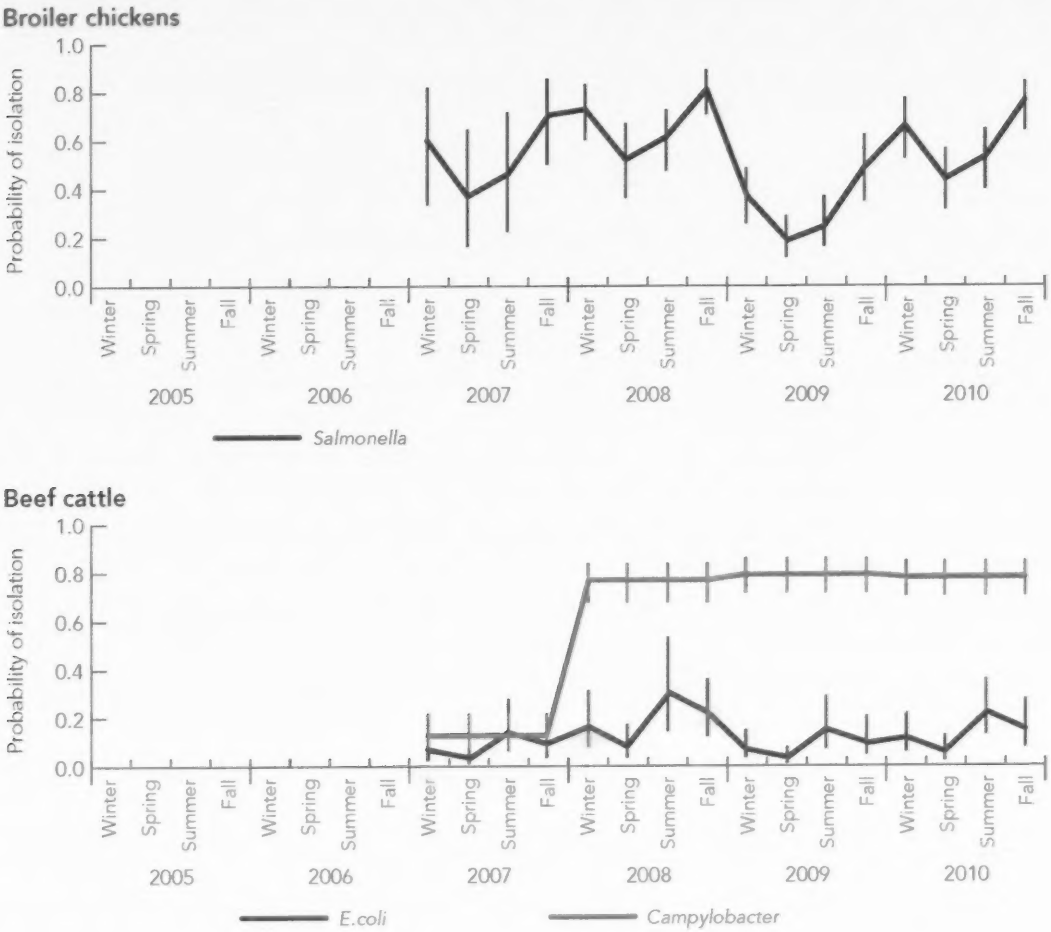
No significant effect was identified for season or year on the probability of *E. coli* O157:H7 isolation from dairy cattle feces, which was expected given the stable recovery rate of 5%. In contrast, season and year were significant predictors of *Salmonella* isolation, which peaked in the winter and spring and varied slightly by year (Figure 11.4). Finally, year was a significant predictor of *Campylobacter* isolation, which was attributable to a large increase in isolation rates from 2007 to 2008. However, this effect reflected the change in laboratory isolation methods previously mentioned for swine feces and is, therefore, not a true reflection of an increase in *Campylobacter* contamination on farms.

BEEF CATTLE

In contrast to results for dairy cattle feces, season and year had no effect on the probability of *Salmonella* isolation from beef cattle feces, again because of a stable recovery rate at less than 13%. Also different from dairy cattle fecal results, season and year were significant predictors of *E. coli* O157:H7 isolation from beef cattle feces, which was highest during the summer season (Figure 11.4). Similar to the dairy cattle and swine results, year was a significant predictor of *Campylobacter* isolation, the prevalence of which increased sharply from 2007 to 2008, again reflecting the change in laboratory methods.

FIGURE 11.4. Predicted probabilities and 95% confidence intervals for isolation of *Campylobacter*, *Yersinia*, *Salmonella*, and *E. coli* O157:H7 from fecal samples collected from farms in the ON site from 2005 through 2010.





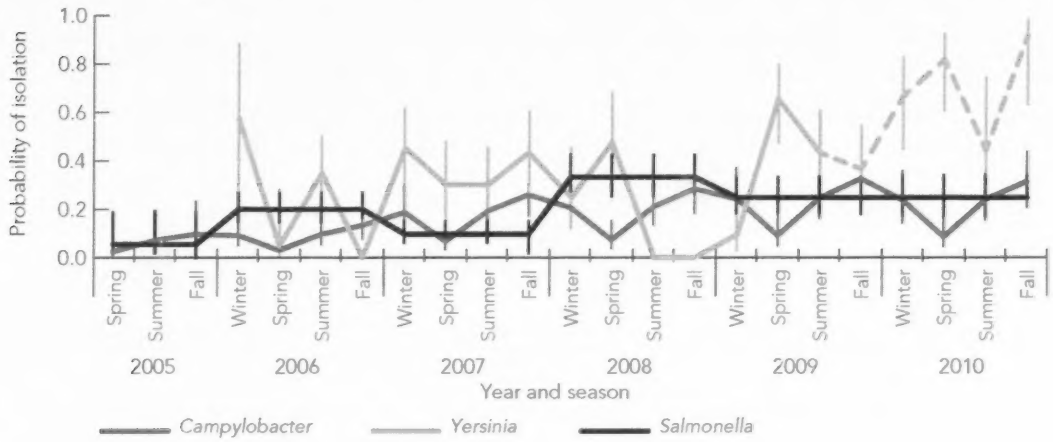
NOTE: Dashed lines indicate the point at which new laboratory isolation methods were initiated.

WATER

Data from all five collection sites along the Grand River (in the ON site) were combined to build multivariable logistic models to estimate the probability of pathogen isolation from samples of untreated surface water.

No significant effects of season or year were detected for *Cryptosporidium*, VTEC, or *Giardia* isolation from the water samples. These results were expected, given that *Cryptosporidium* and *Giardia* are consistently isolated at high rates (greater than 85% and greater than 90%, respectively) from water samples, whereas samples are consistently free of VTEC (less than 4% of isolates per year). In contrast, season, year, and an interaction between the two variables were significant predictors of *Yersinia* isolation. The probability of *Yersinia* isolation from water samples was higher between 2009 and 2010 than in previous years, however this can be explained by a method effect (Figure 11.5). Season and year were significant predictors of *Campylobacter* isolation, which peaked in the fall, and has been increasing each year (Figure 11.5). Finally, the probability of *Salmonella* isolation varied significantly by year, with the highest prevalence in 2008.

FIGURE 11.5. Predicted probabilities and 95% confidence intervals for isolation of *Campylobacter*, *Yersinia*, and *Salmonella* from untreated surface water samples in the ON site from 2005 through 2010.



NOTE: Dashed lines indicate the point at which new laboratory isolation methods were initiated.

11.2.2 Food

As described for the farm animal exposure sources, multivariable logistic models were used to estimate the probability of enteric pathogen isolation from retail samples of pork, chicken, and beef.

PORK

No significant effect of season or year was detected for *Campylobacter*, *Salmonella*, VTEC, or *Listeria* isolation from retail pork samples. These pathogens were isolated at low rates from mid-2005 through 2010: less than 10% of samples per quarter were positive for *Campylobacter*, *Salmonella*, and VTEC, and less than 20% were positive for *Listeria*. In contrast, season and year were significantly associated with the probability of *Yersinia* isolation from retail pork. Large increases in the prevalence of *Yersinia* contamination were evident from 2009 to 2010, however this could also be due to a method effect (Figure 11.6).

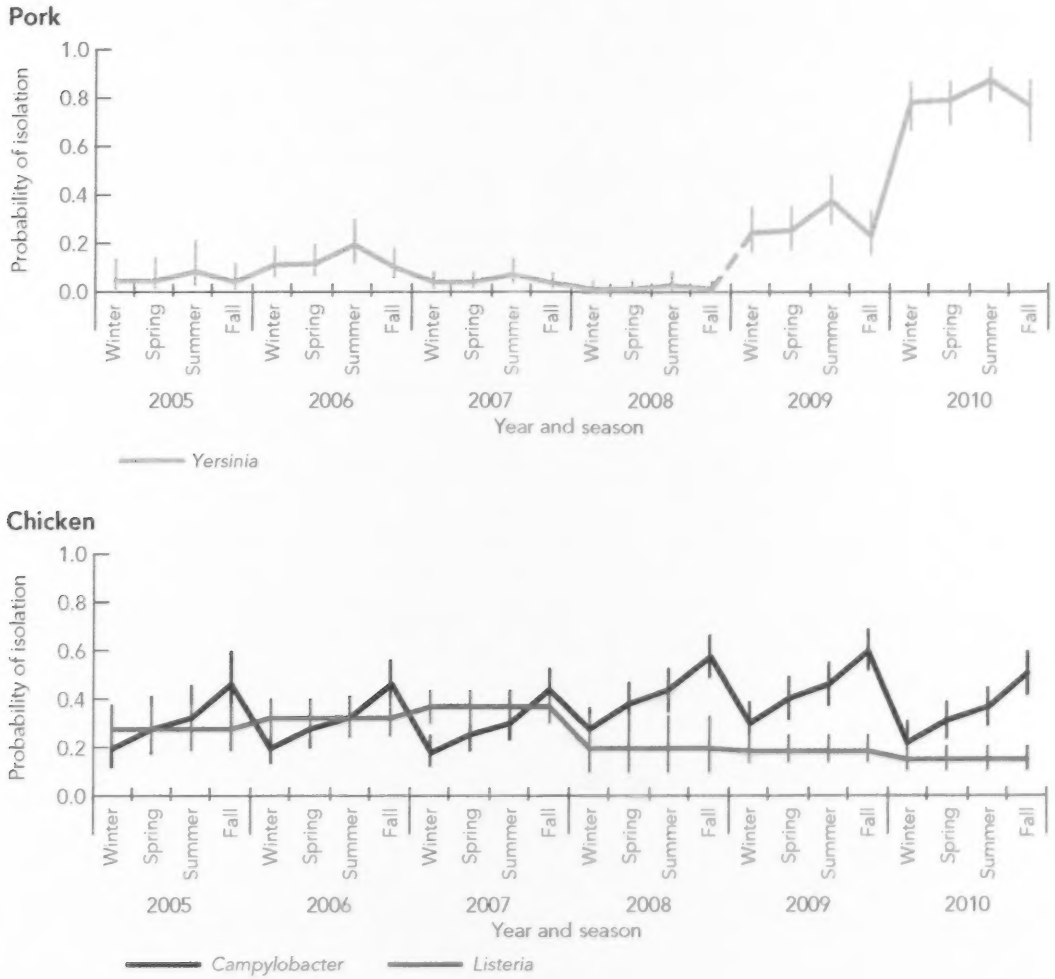
CHICKEN

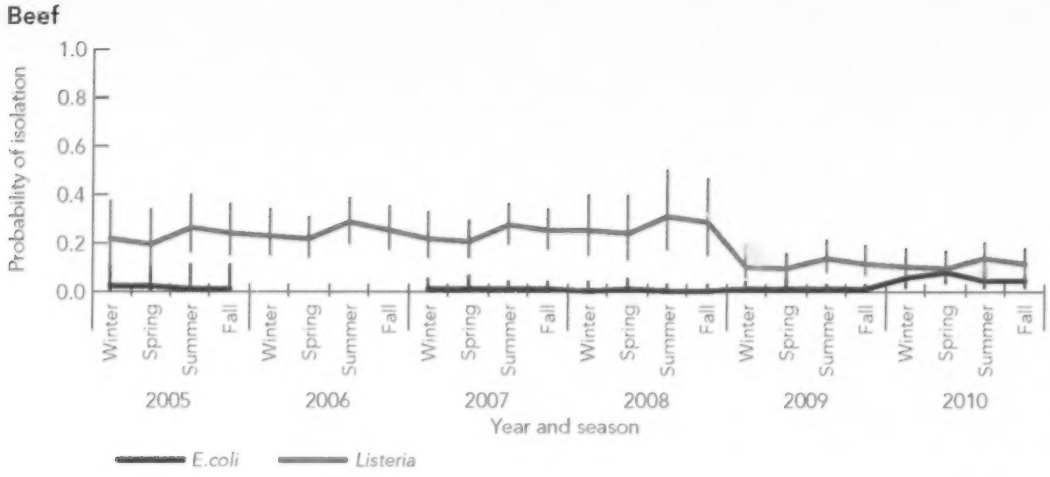
Neither season nor year significantly influenced the probability of *Salmonella* or VTEC isolation from retail chicken samples. Consistency in the prevalence of *Salmonella* contamination over time accounts for these results, with approximately 30% of samples testing positive throughout the surveillance period. Although 30% may seem high from a consumer perspective, these model results suggest that the probability of contamination is not increasing. In contrast, VTEC was very rarely isolated from chicken samples. Season and year were significantly associated with the probability of *Campylobacter* isolation, with peaks consistently evident during the fall, slight increases occurring from 2007 through 2009, and a decrease observed from 2009 through 2010 (Figure 11.6). Finally, year was a significant predictor of the *Listeria* isolation, with the probability increasing from 2005 to 2007, followed by a decrease from 2007 through 2010.

BEEF

Season and year had no effect on the probability of *Campylobacter* or *Salmonella* isolation from retail beef, which remained low over time. In contrast, season and year were significantly associated with VTEC and *Listeria* isolation. The prevalence of VTEC contamination in beef samples was low for most of the surveillance period; however, a significant increase was evident in 2010 (Figure 11.6). The prevalence of *Listeria* contamination increased from 2005 through 2008 but decreased afterward.

FIGURE 11.6. Predicted probabilities and 95% confidence intervals for isolation of enteric pathogens from retail meat samples from 2005 through 2010.





NOTE: Dashed lines indicate the point at which new laboratory isolation methods were initiated.

11.3 Importance of Recognizing Laboratory Changes

FoodNet Canada data have been greatly affected by laboratory changes from 2005 to 2010. For example, a more sensitive *Campylobacter* isolation method was adopted by FoodNet Canada laboratories in January 2008. By increasing test sensitivity, a sudden increase was seen in the proportion of *Campylobacter*-positive fecal samples from swine, dairy cattle, and beef cattle farms (Figure 11.4). Another change in laboratory protocols in June 2009 increased the sensitivity of *Yersinia* isolation techniques for water and retail meat samples (Figure 11.5).

Second, even with awareness of changes in laboratory protocols, the changes make it difficult to interpret long-term surveillance trends. Data prior to the change have questionable value, given that those data may not be comparable with those obtained after the change. Therefore, the baseline expected level of contamination is no longer reliable and may not be useful for predictive purposes. Although a new baseline may be established once the new test has been used for a while, use of the new type of data creates problems in data interpretation during the interim.

The original and new laboratory test sensitivity and specificity values can be used to make adjustments to earlier data; however, these values are rarely known or available.

11.4 Assessing Potential Associations among Exposure Source Contamination and the Rate of Human Illness

Given the integrated surveillance design of the FoodNet Canada program, in which data on human cases of enteric disease and exposure source contamination are collected from the same region, it is possible to assess associations among exposures and diseases. Care must be taken to interpret results at the ecological level (at the level of the sentinel site), however, as it is unknown whether the affected individuals were the same ones who reported exposure to any of the sources.

Significant associations at the ecological level may provide information for public health teams within the sentinel sites. Once an association has been established over a period of time, a change in the prevalence and amount of enteric pathogens in the exposure source may predict a corresponding change in the incidence of human disease. Therefore, knowledge of these associations and changes in exposure data may allow the development of strategies to safeguard human health.

To explore any potential statistical associations between frequencies of exposure sources being contaminated and corresponding trends in human illness, case counts were summarized by year and season within the ON site. The proportion of positive results from exposure sources for *Campylobacter*, *Cryptosporidium*, VTEC, *Giardia*, *Salmonella*, and *Yersinia* were also summarized by year and season. Poisson models for case counts of campylobacteriosis, cryptosporidiosis, VTEC infection, giardiasis, salmonellosis, and yersiniosis were developed. The natural logarithm of the ON site population was included as the offset, and the proportion of positive results for the pathogen of interest from all measured exposure sources were used as predictor variables.

The models revealed that no statistically significant associations exist in the current data between exposure source contamination and disease incidence in the ON site. However, because of the small number of data points, the modeling process should be repeated when more data become available to increase the power to detect significant associations. Furthermore, the fallacy of composition must be taken into account: if many exposure sources contribute to the case counts for a given illness, then dilution across exposure sources may result in a non-significant result in statistical models.

12. SOURCE ATTRIBUTION

Two of the core objectives of the FoodNet Canada surveillance program are as follows:

- Surveillance—to detect changes in trends of human enteric disease incidence and pathogen exposure levels from water, food, and animal sources.
- Human illness source attribution[1]—to determine the proportion of human cases of illness attributable to water, food, and animal sources.

Because the surveillance program is still in development in terms of the number of implemented sentinel sites, the source attribution activities have been limited in their scope and impact. However, the program team continues to plan and implement several projects to refine methodologies and develop preliminary estimates with respect to source attribution to inform food and water safety policy as well as the prevention and control of human infectious gastrointestinal illness in Canada (Table 12.1).

Source attribution activities are being pursued across the world. Methods advocated to generate estimates of source attribution include the following:

1. Microbial approaches
    a. Microbial typing
    b. Comparative exposure assessment
2. Epidemiological studies
    c. Sporadic illness: case-control studies
    d. Sporadic illness: case-case studies
    e. Sporadic illness: cohort studies
    f. Outbreak-related illness: outbreak data summaries
3. Intervention studies
4. Expert elicitation

Each of these methods has its specific advantages and limitations, and none yields accurate estimates for source attribution on its own[1].

Given that all of the aforementioned methods are oriented toward a particular type of case (sporadic vs. outbreak-related) and nature of source (reservoir vs. vehicle), each provides a different perspective on the source of contamination and inherently addresses different policy issues. While in the expansion phase of its surveillance program, FoodNet Canada is endeavouring to make use of all methods to refine future source attribution efforts.

[1] Human illness source attribution may be defined as the partitioning of the human disease burden of one or more foodborne infections to specific sources, where the term source includes animal reservoirs and vehicles (e.g. foods) (19).

TABLE 12.1. FoodNet Canada plan and achievements with regard to source attribution in 2010.

OBJECTIVE, BY APPROACH	DATA USED	MAIN RESULTS AND CONCLUSIONS	MAIN OUTPUT	STATUS
1. Microbial approaches				
1.a) Informal, descriptive comparison of pathogen subtypes between the affected people and the potential sources of exposure	Annual subtyping data (e.g. serotypes, phage types, PFGE patterns) obtained through FoodNet Canada's active water, food, and animal surveillance and the enhanced human surveillance in its ON site	Travel- and non-travel-related human cases differ in terms of pathogen subtype (e.g. *Salmonella* serotype and phage type). Overall, the match between subtypes isolated from human cases and those isolated from possible sources is weak to limited	FoodNet Canada Annual Reports for 2006–2009 (particularly the section Exposure Sources in the 2007 Annual Report)	Done; performed annually
1.b) Adaptation of the Danish *Salmonella* source account model to the Canadian data	Published serotyping and phage typing data from the NML for human isolates and serotyping and phage typing results from the LFZ and CFIA for source isolates Data between 2003 and 2007	Data analysis planned for second half of 2010	Expected publication in 2013	In progress
1.c) *Campylobacter* comparative risk exposure assessment	Data on detection and quantity of *Campylobacter* in retail meat, on farms, and in water collected through FoodNet Canada in its ON site, plus additional data collected in the same area from other sources	Started in 2011	Expected publication in 2013	Planned
2. Epidemiological studies				
2.a) Enteric disease Healthy Control Study	Data on hypothesized risk factors for enteric disease cases over a 12-month period as collected through the enhanced human surveillance in FoodNet Canada's ON site, plus similar da ta for controls enrolled in the same area over the same period in an episodic study undertaken by FoodNet Canada through a contract	Data collected for the healthy control group between August 2009 and July 2010; data analyzed in late 2010	Expected publication in 2012	In progress/ planned
2.b) General case-case comparison	Data on hypothesized risk factors for human enteric disease cases collected yearly through FoodNet Canada in its ON site	Hypothesized risk factors for each enteric disease, pointing out some specific potential sources, with no formal statistical test	FoodNet Canada Annual Reports for 2006–2009	Done; performed annually

3. Intervention studies				
4. Expert elicitation				
5. Miscellaneous				
5.a) Seasonality in human campylobacteriosis cases and exposure sources	Campylobacter data obtained through FoodNet Canada surveillance activities from May 2005 to December 2010 on monthly number of human cases and monthly prevalence of *Campylobacter jejuni* in chicken meat at retail and in surface waters are used in the analyses. Behavioral data on the monthly frequency of barbequing and swimming in natural waters are extracted from the interviews of all cases with enteric diseases as an indicator for the frequency in the general population. The seasonality is assessed as well as the long term trend for each series. The link between the sources of contamination or the exposure behaviours and the cases is assessed through regression with autocorrelated errors and transfer functions.	Analysis in progress	Poster presentation at Innovet 2012 Oral communication at Canadian *Campylobacter* Workshop 2012 Publication expected in 2012	In progress

CFIA = Canadian Food Inspection Agency.
LFZ = Laboratory for Foodborne Zoonoses.
PFGE = Pulsed-field gel electrophoresis.

APPENDIX A — LABORATORY TESTS PERFORMED TO IDENTIFY PATHOGENS IN SAMPLES COLLECTED THROUGH FOODNET CANADA SURVEILLANCE SYSTEM

COMPONENT	SAMPLE TYPE	SPECIATION OR MICROSCOPIC ID	MOLECULAR ID	ENUMERATION (MPN)	SEROTYPING	PHAGE TYPING	BIBOTYPING	AMR	PFGE	GENOTYPING
Retail meat	Skin-off chicken breasts, ground beef, pork chops	Continuous: *Campylobacter* *Listeria* *Salmonella* VTEC *Yersinia* (pork only)	ND	*Campylobacter* *Salmonella* *Yersinia*	*Salmonella* *Yersinia*	*Salmonella*	*Listeria*	ND	*Listeria* *Salmonella*	ND
Retail produce	Bagged leafy greens	Episodic: *Campylobacter* *Cyclospora* *Cryptosporidium* Generic *Escherichia coli* *Giardia* *Listeria monocytogenes* *Salmonella* VTEC	Episodic: *Shigella* Norovirus Rotavirus	ND	*Listeria* *Salmonella* VTEC	*Salmonella*	*Listeria*	ND	*Listeria* *Salmonella* VTEC	*Cryptosporidium* *Cyclospora* *Giardia* Norovirus Rotavirus
On-farm	Fresh and stored pooled fecal samples from dairy and beef cattle, swine, and broiler chickens	Continuous: *Campylobacter* *E. coli* O157:H7 *Salmonella* *Yersinia* (pork only)	ND	ND	*Listeria* *Salmonella* *Yersinia*	*Salmonella*	*Listeria*	ND	*E. coli* O157:H7 *Salmonella*	ND

COMPONENT	SAMPLE TYPE	SPECIATION OR MICROSCOPIC ID	MOLECULAR ID	ENUMERATION (MPN)	SEROTYPING	PHAGE TYPING	RIBOTYPING	AMR	PFGE	GENOTYPING
Water	Raw surface water	*Campylobacter* *Cryptosporidium* *E. coli* O157:H7 *Giardia* *Salmonella* *Yersinia*	ND	ND	*Salmonella* *Yersinia*	*Salmonella*	ND	ND	*E. coli* O157:H7 *Salmonella*	*Cryptosporidium*
Human	Fecal samples	*Campylobacter* *Cryptosporidium* *E. coli* O157:H7 *Giardia* *Listeria* *Salmonella* *Shigella* *Yersinia*	ND	ND	*Salmonella* *Listeria* *Yersinia*	*Salmonella*	ND	*Campylobacter* *Salmonella*	*E. coli* O157:H7 *Salmonella*	ND

AMR = Antimicrobial resistance.
ID = Identification.
MPN = Most probable number of organisms.
ND = Not done.
PFGE = Pulsed-field gel electrophoresis.
VTEC = Verotoxigenic *Escherichia coli*.

APPENDIX B — QUESTIONNAIRE RESULTS

APPENDIX B.1. QUESTIONNAIRE RESPONSE RATES AND PERCENTAGES OF HUMAN ENTERIC DISEASE CASES WITH REPORTED EXPOSURE TO PUTATIVE SOURCES OF INFECTION IN THE ON SITE IN 2010.

EXPOSURE	AMOEBIASIS		CAMPYLOBACTERIOSIS		CRYPTOSPORIDIOSIS		*E. COLI* O157:H7		GIARDIASIS		SALMONELLOSIS		YERSINIOSIS		TOTAL NO. OF CASES
	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	
Total No. of endemic cases	12	276	112	176	13	275	12	278	50	238	82	206	7	281	288
No. of cases with exposure data	10	234	94	150	8	236	12	234	44	200	70	174	6	238	244
Percentage (%) with exposure data	83	85	84	85	62	86	100	84	88	84	85	85	86	85	85
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Main water from private well	0	15	23	9	0	15	25	14	7	16	10	16	0	15	14
Municipal water supply	50	61	60	61	88	60	67	60	61	61	60	61	50	61	61
Drank untreated water	0	5	8	3	0	5	0	5	7	5	3	6	0	5	5
Swam	10	24	27	21	63	22	17	24	27	23	16	26	17	24	23
In a lake	0	7	6	7	25	6	8	6	16	5	0	9	0	7	7
In a pool	10	15	17	13	38	14	8	15	9	16	13	15	17	14	14
In a river	0	3	1	3	13	2	0	3	7	2	1	3	0	3	2
Drank unpasteurized milk	0	3	6	1	13	3	8	3	0	4	0	5	0	3	3
Ate undercooked food	10	8	7	8	0	8	17	7	7	8	9	8	0	8	8
Attended a barbecue	30	26	34	21	13	27	25	26	36	24	12	32	17	27	26
Ate in a restaurant	30	32	34	30	25	32	58	30	34	31	26	34	0	32	32
Ate meat from butcher shop	10	8	11	6	13	8	17	7	7	8	3	10	0	8	8

EXPOSURE	AMOEBIASIS		CAMPYLOBACTERIOSIS		CRYPTOSPORIDIOSIS		E. COLI O157:H7		GIARDIASIS		SALMONELLOSIS		YERSINIOSIS		TOTAL NO. OF CASES
	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	
Ate privately slaughtered meat	0	4	7	1	0	4	8	3	0	5	1	5	0	4	4
Shopped at butcher shop	14	9	10	9	0	10	25	8	10	9	6	10	0	10	9
Contact with household pet	30	58	67	50	63	56	42	57	31	62	62	55	83	56	57
Cats	20	23	27	21	38	22	8	24	11	26	27	21	17	23	23
Dogs	10	41	54	31	38	40	33	40	18	45	37	41	67	39	40
Reptiles	0	1	1	1	0	1	0	1	0	2	3	1	0	1	1
Visited farm, petting zoo or fair	10	10	13	9	38	9	17	10	10	11	4	13	0	11	10
Cats	0	1	0	1	13	0	0	1	0	1	0	1	0	1	1
Dogs	0	1	2	1	0	1	0	1	2	1	0	2	0	1	1
Horses	0	1	1	1	13	1	0	1	0	1	0	1	0	1	1
Cattle	10	2	1	3	13	2	8	2	0	3	1	2	0	2	2
Pigs	0	1	0	1	0	1	0	1	0	1	1	0	0	1	1
Poultry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lived on a farm/ rural site	0	14	21	9	0	14	25	13	2	16	13	14	0	14	14
On-farm animal exposure															
Cats	0	3	5	1	0	3	8	3	0	4	1	3	0	3	3
Dogs	0	3	4	1	0	3	8	2	0	3	1	3	0	3	3
Horses	0	4	6	2	0	4	8	4	0	5	3	4	0	4	4
Cattle	0	7	12	4	0	7	25	6	2	8	3	9	0	7	7
Pigs	0	3	0	4	0	3	17	2	2	3	4	2	0	3	3
Poultry	0	4	6	3	0	4	8	4	2	5	3	5	0	4	4
Sheep	0	1	3	0	0	1	0	1	0	2	0	2	0	1	1

Pairs of data highlighted with blue for each disease differ by at least 20%. No differences were highlighted if there were less than ten cases with exposure data.

OTHERS = Cases of enteric disease other than the disease indicated.

APPENDIX B.2. QUESTIONNAIRE RESPONSE RATES AND PERCENTAGES OF HUMAN ENTERIC DISEASE CASES WITH REPORTED EXPOSURE TO PUTATIVE SOURCES OF INFECTION IN THE BC SITE IN 2010.

EXPOSURE	CAMPYLOBACTERIOSIS		CRYPTOSPORIDIOSIS		VEROTOXIGENIC *E. COLI* INFECTION		GIARDIASIS		SALMONELLOSIS		YERSINIOSIS		TOTAL NO. OF CASES
	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	
Total No. of endemic cases	89	128	2	215	9	208	37	180	56	161	24	193	217
No. of cases with exposure data	82	101	2	181	7	176	22	161	52	131	18	165	183
Percentage (%) with exposure data	92	79	100	84	78	85	59	89	93	81	75	85	84
	%	%	%	%	%	%	%	%	%	%	%	%	%
Main water from private well	4	3	0	3	0	3	9	2	2	4	0	4	3
Municipal water supply	78	72	100	75	100	74	59	77	75	75	67	76	75
Drank untreated water	10	6	0	8	14	7	24	6	0	11	0	9	8
Swam	20	18	50	18	14	19	43	16	12	22	6	20	19
In a lake	7	4	0	6	0	6	19	4	0	8	0	6	6
In a pool	13	9	50	11	14	11	10	11	8	12	6	12	11
In a river	2	1	0	2	0	2	5	[illegible]	0	2	0	8	2
Drank unpasteurized milk	5	1	0	3	14	2	0	[illegible]	0	4	0	3	3
Ate undercooked food	9	4	0	6	0	6	0	7	4	7	13	6	6
Attended a barbecue	13	10	50	11	33	11	5	13	12	12	0	13	12
Ate in a restaurant	45	30	0	37	43	37	43	36	19	44	44	36	37
Ate meat from butcher shop	1	4	0	3	0	3	5	3	6	2	0	3	3

EXPOSURE	CAMPYLOBACTERIOSIS		CRYPTOSPORIDIOSIS		VEROTOXIGENIC *E. COLI* INFECTION		GIARDIASIS		SALMONELLOSIS		YERSINIOSIS		TOTAL NO. OF CASES
	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	Cases	Others	
Ate privately slaughtered meat	0	3	0	2	29	1	0	2	2	2	0	2	2
Shopped at butcher shop	6	15	0	11	0	12	11	11	21	7	10	11	11
Contact with household pet	60	58	100	59	57	59	52	60	67	56	33	61	59
Cats	20	30	0	26	0	26	24	25	43	18	13	27	25
Dogs	46	38	100	41	43	42	43	41	35	44	27	43	42
Reptiles	1	8	100	4	0	5	0	6	12	2	0	6	5
Visited farm, petting zoo or fair	16	7	0	11	43	10	10	11	4	14	0	12	11
Cats	0	0	0	0	0	0	0	0	0	0	0	0	0
Dogs	0	0	0	0	0	0	0	0	0	0	0	0	0
Horses	1	2	0	2	14	1	5	1	0	2	0	2	2
Cattle	5	3	0	4	29	3	0	4	2	5	0	4	4
Pigs	0	0	0	0	0	0	0	0	0	0	0	0	0
Poultry	4	0	0	2	0	2	0	2	0	2	0	2	2
Lived on a farm/ rural site	5	10	0	8	14	7	24	6	8	8	0	9	8
On-farm animal exposure													
Cats	0	0	0	0	0	0	0	0	0	0	0	0	0
Dogs	0	0	0	0	0	0	0	0	0	0	0	0	0
Horses	0	1	0	1	0	1	0	1	2	0	0	1	1
Cattle	0	2	0	1	14	1	0	1	2	1	0	1	1
Pigs	0	0	0	0	0	0	0	0	0	0	0	0	0
Poultry	2	3	0	3	0	3	0	3	6	2	0	3	3
Sheep	0	2	0	1	0	1	0	1	4	0	0	1	1

Pairs of data highlighted with blue for each disease differ by at least 20%. No differences were highlighted if there were less than 10 cases with exposure data.

OTHERS = Cases of enteric disease other than the disease indicated.

APPENDIX C — ENUMERATION RESULTS (ORGANISM COUNTS) FOR SAMPLES OF RETAIL PORK, CHICKEN, AND BEEF IN THE ON SITE IN 2010

PATHOGEN, BY COMMODITY	NO. OF SAMPLES TESTED	NO. OF POSITIVE RESULTS	MOST PROBABLE NUMBER OF ORGANISMS/G OF SAMPLE				
			BDL (< 0.3)	0.3–10	11–100	101–1,000	> 1,000
Campylobacter							
Pork	197	3	3	0	0	0	0
Chicken	197	71	53	17	0	1	0
Beef	197	1	0	1	0	0	0
Listeria							
Pork	182	15	9	4	0	1	1
Chicken	197	27	17	10	0	0	0
Beef	197	23	12	9	2	0	0
Salmonella							
Pork	197	3	2	1	0	0	0
Chicken	197	57	51	3	3	0	0
Beef	197	1	1	0	0	0	0
Yersinia							
Pork[1]	105	86	2	9	4	9	23

BDL = Below the assay detection limit.

[1] Not all positive samples were enumerated.

APPENDIX D — SUPPLEMENTAL TABLES

TABLE D.1. Pulsed-field gel electrophoresis patterns identified in isolates of *Escherichia coli* O157:H7 obtained through FoodNet Canada surveillance between 2005 and 2010.

PATTERN	HUMAN	SWINE	BEEF CATTLE	DAIRY CATTLE	WATER[b]
	Endemic cases ON site				
ECXAI.0001	6	0	3	1	0
ECXAI.0002	1	0	0	0	0
ECXAI.0007	1	0	0	0	0
ECXAI.0008	3	0	2	1	1
ECXAI.0012	0	0	1	0	0
ECXAI.0014	0	0	2	0	0
ECXAI.0017	3	0	0	0	0
ECXAI.0023	0	0	0	1	0
ECXAI.0052	3	0	0	0	0
ECXAI.0063	1	0	0	0	0
ECXAI.0073	0	0	1	0	0
ECXAI.0096	1	0	0	0	0
ECXAI.0221	1	0	0	0	0
ECXAI.0247	1	0	0	0	0
ECXAI.0262	9	0	0	0	0
ECXAI.0266	0	0	2	0	0
ECXAI.0309	1	0	0	0	0
ECXAI.0317	0	0	0	1	0
ECXAI.0378	0	0	0	1	0
ECXAI.0407	0	0	2	0	0
ECXAI.0478	1	0	0	0	0
ECXAI.0776	0	0	1	0	0
ECXAI.0816	1	0	0	0	0
ECXAI.0825	0	0	3	0	0
ECXAI.1164	1	0	1	1	0
ECXAI.1175	1	0	0	0	0
ECXAI.1182	0	0	0	1	0
ECXAI.1186	1	0	0	0	0
ECXAI.1206	1	0	0	0	0
ECXAI.1216	0	1	0	0	0
ECXAI.1239	1	0	0	0	0
ECXAI.1248	1	0	0	0	0
ECXAI.1267	0	0	1	1	0
ECXAI.1288	0	0	3	0	0
ECXAI.1301	1	0	2	0	0

PATTERN	HUMAN	SWINE	BEEF CATTLE	DAIRY CATTLE	WATER[b]
	Endemic cases ON site				
ECXAI.1304	0	0	0	1	0
ECXAI.1310	0	0	1	0	0
ECXAI.1325	0	0	0	1	0
ECXAI.1398	0	0	0	0	1
ECXAI.1456	1	0	0	0	0
ECXAI.1477	1	0	0	0	0
ECXAI.1478	1	0	0	0	0
ECXAI.1495	1	0	0	0	0
ECXAI.1501	1	0	0	0	0
ECXAI.1526	1	0	0	0	0
ECXAI.1537	1	0	0	0	0
ECXAI.1538	0	0	1	0	0
ECXAI.1556	0	0	0	0	1
ECXAI.1557	0	0	0	0	1
ECXAI.1578	1	0	0	0	0
ECXAI.1599	0	0	0	1	0
ECXAI.1610	1	0	0	0	0
ECXAI.1611	0	0	0	1	0
ECXAI.1612	0	0	0	2	0
ECXAI.1613	0	0	0	1	0
ECXAI.1614	0	0	0	1	0
ECXAI.1687	0	0	0	2	0
ECXAI.1688	0	0	0	1	0
ECXAI.1689	0	0	0	1	0
ECXAI.1690	0	0	0	1	0
ECXAI.1691	0	0	0	1	0
ECXAI.1692	1	0	0	1	0
ECXAI.1694	1	0	0	0	0
ECXAI.1714	1	0	0	0	0
ECXAI.1737	2	0	0	0	0
ECXAI.1777	1	0	0	0	0
ECXAI.1844	0	0	0	0	1
ECXAI.1845	0	0	0	1	0
ECXAI.1855	0	0	0	1	0
ECXAI.1857	0	0	0	1	0
ECXAI.1858	0	0	1	0	0
ECXAI.1859	0	0	1	0	0
ECXAI.1860	0	0	1	0	0
ECXAI.1898	1	0	0	0	0
ECXAI.1901	1	0	0	0	0

PATTERN	HUMAN	SWINE	BEEF CATTLE	DAIRY CATTLE	WATER[b]
	Endemic cases ON site				
ECXAI.1940	1	0	0	0	0
ECXAI.1972	1	0	0	0	0
ECXAI.2003	0	0	0	1	0
ECXAI.2108	0	0	1	0	0
ECXAI.2109	0	0	0	1	0
ECXAI.2110	0	0	2	0	0
ECXAI.2111	0	1	0	0	0
ECXAI.2112	0	0	0	1	0
ECXAI.2172	0	0	1	0	0
ECXAI.2239	1	0	0	0	0
ECXAI.2303	1	0	0	0	0
ECXAI.2324	0	1	0	0	0
ECXAI.2325	0	1	0	0	0
ECXAI.2327	0	0	1	0	0
ECXAI.2328	0	0	0	1	0
ECXAI.2329	0	0	0	1	0
ECXAI.2330	0	0	2	0	0
ECXAI.2378	0	0	0	1	0
ECXAI.2379	0	0	1	0	0
ECXAI.2380	0	0	1	0	0
ECXAI.2381	0	1	0	0	0
ECXAI.2382	0	0	1	0	0
ECXAI.2464	0	0	0	2	2
ECXAI.2481	0	0	0	1	1
ECXAI.2532	0	1	0	0	1
ECXAI.2547	0	0	1	0	1
ECXAI.2550	0	0	1	0	1
ECXAI.2551	0	0	0	0	1
ECXAI.2552	0	0	0	1	1
ECXAI.2553	0	0	1	0	1
ECXAI.2554	0	0	1	0	1
ECXAI.2555	0	0	1	0	1
ECXAI.2556	0	0	0	1	1
ECXAI.2607	0	0	3	3	0
Not O157:H7	0	0	0	0	1
Grand Total	**61**	**6**	**47**	**40**	**18**

[a] Fecal samples were collected from 30 farms in the ON site for each type of food animal.

[b] Samples of untreated surface water were collected from five sites along the Grand River in the ON site: Canagagigue Creek (A), Conestogo River (B), Upper Grand River (C), Grand River near drinking water intake (D), and Grand River, near a wastewater treatment plant effluent point (E).

TABLE D.2. Pulsed-field gel electrophoresis patterns identified in isolates of *Listeria monocytogenes* obtained through FoodNet Canada surveillance between 2005 and 2010.

PATTERN	HUMAN		RETAIL				ON-FARM[a]			
	Endemic cases ON site	Endemic cases BC site	Pork chops	Chicken breasts	Ground beef	Bagged leafy greens	Swine	Broiler chickens	Beef cattle	Dairy cattle
LMAAI.0001	1	0	19	3	6	0	0	0	0	0
LMAAI.0003	1	0	1	1	1	0	0	0	0	0
LMAAI.0007	0	0	0	0	0	0	0	0	3	0
LMAAI.0013	0	0	30	13	34	0	0	0	0	0
LMAAI.0014	0	0	0	1	0	0	0	0	0	0
LMAAI.0015	0	0	3	0	0	0	0	0	0	0
LMAAI.0017	0	0	0	0	0	0	0	0	1	0
LMAAI.0019	0	0	1	0	0	0	0	0	0	0
LMAAI.0024	0	0	3	4	6	0	0	0	0	0
LMAAI.0026	0	0	0	1	0	0	0	0	0	0
LMAAI.0028	0	0	5	2	2	0	0	0	0	0
LMAAI.0042	0	0	1	0	0	0	0	0	0	0
LMAAI.0043	0	0	0	0	1	0	0	0	0	0
LMAAI.0047	0	0	1	0	0	0	0	0	0	0
LMAAI.0049	0	0	2	0	1	0	0	0	2	0
LMAAI.0054	0	0	0	0	1	0	0	0	0	0
LMAAI.0061	0	0	1	0	0	0	0	0	0	0
LMAAI.0067	0	0	0	0	1	0	0	0	0	0
LMAAI.0074	0	0	3	0	0	0	0	0	2	1
LMAAI.0080	0	0	2	0	0	0	0	0	0	0
LMAAI.0087	0	0	0	1	0	0	0	0	0	0
LMAAI.0090	0	0	0	0	0	0	0	0	1	1
LMAAI.0093	1	0	0	0	1	0	0	1	11	0
LMAAI.0096	0	0	0	0	0	6	0	0	0	0
LMAAI.0097	0	0	10	0	0	0	0	0	0	0
LMAAI.0101	0	0	0	0	2	0	0	0	0	0
LMAAI.0113	0	0	0	0	0	0	0	0	0	1
LMAAI.0118	0	0	0	0	1	0	0	0	0	0
LMAAI.0126	0	0	5	3	6	0	0	0	5	0
LMAAI.0128	0	0	0	0	0	0	0	0	1	0
LMAAI.0130	0	0	0	0	0	0	0	0	1	0
LMAAI.0147	0	0	0	7	0	0	0	0	0	0
LMAAI.0160	0	0	1	0	0	0	0	0	0	0
LMAAI.0165	0	0	0	2	0	0	0	0	1	0
LMAAI.0182	0	0	0	0	0	0	1	0	0	0

PATTERN	HUMAN		RETAIL				ON-FARM[a]			
	Endemic cases ON site	Endemic cases BC site	Pork chops	Chicken breasts	Ground beef	Bagged leafy greens	Swine	Broiler chickens	Beef cattle	Dairy cattle
LMAAI.0193	0	0	7	0	0	0	0	0	1	0
LMAAI.0204	0	0	0	0	0	1	0	0	9	5
LMAAI.0207	0	0	0	0	0	0	0	0	1	0
LMAAI.0213	0	0	0	0	1	0	0	0	0	0
LMAAI.0214	0	0	2	0	0	0	0	0	0	0
LMAAI.0223	0	0	2	9	45	0	0	0	0	0
LMAAI.0234	0	0	0	0	0	1	0	0	0	0
LMAAI.0256	0	0	0	1	1	0	0	0	0	0
LMAAI.0259	0	0	0	0	0	0	0	0	1	0
LMAAI.0265	1	0	0	0	0	0	0	0	0	0
LMAAI.0266	0	0	0	0	0	0	0	0	5	0
LMAAI.0269	0	0	1	0	0	0	0	0	0	0
LMAAI.0287	0	0	3	0	1	0	0	0	0	0
LMAAI.0317	0	0	0	0	1	0	0	0	1	0
LMAAI.0333	0	0	0	0	0	0	0	0	1	1
LMAAI.0352	0	0	1	0	0	1	0	0	0	0
LMAAI.0354	0	0	0	0	0	0	0	0	0	1
LMAAI.0360	0	0	2	0	0	0	0	0	0	0
LMAAI.0365	0	0	0	0	0	1	0	0	0	0
LMAAI.0368	0	0	0	0	0	0	0	0	1	0
LMAAI.0371	0	0	1	0	1	0	0	0	0	0
LMAAI.0377	0	0	3	0	0	0	0	0	0	0
LMAAI.0378	0	0	0	5	2	0	0	0	0	0
LMAAI.0379	0	0	0	1	0	0	0	0	0	0
LMAAI.0380	0	0	0	1	0	0	0	0	0	0
LMAAI.0381	0	0	2	0	0	0	0	0	0	0
LMAAI.0382	0	0	0	0	3	0	0	0	0	0
LMAAI.0383	0	0	4	0	0	0	0	0	0	0
LMAAI.0384	0	0	0	5	2	0	0	0	0	0
LMAAI.0392	0	0	1	0	0	0	0	1	0	0
LMAAI.0402	0	0	12	0	0	0	0	0	0	0
LMAAI.0403	0	0	0	0	0	0	0	1	0	0
LMAAI.0404	0	0	0	0	0	0	0	1	0	0
LMAAI.0407	0	0	0	0	0	0	0	0	1	0
LMAAI.0409	0	0	0	0	0	0	0	0	1	0
LMAAI.0411	0	0	1	1	0	0	0	0	1	0
LMAAI.0413	0	0	0	0	0	0	0	0	1	0
LMAAI.0414	0	0	0	0	0	0	0	0	1	0
LMAAI.0415	0	0	0	0	0	0	0	0	1	0
LMAAI.0418	0	0	0	0	0	0	0	0	1	0

PATTERN	HUMAN		RETAIL				ON-FARM*			
	Endemic cases ON site	Endemic cases BC site	Pork chops	Chicken breasts	Ground beef	Bagged leafy greens	Swine	Broiler chickens	Beef cattle	Dairy cattle
LMAAI.0420	0	0	0	0	0	0	0	0	1	0
LMAAI.0421	0	0	0	0	0	0	0	0	1	0
LMAAI.0423	1	0	0	1	0	0	0	0	1	0
LMAAI.0424	0	0	0	0	0	0	0	0	1	0
LMAAI.0425	0	0	0	0	0	0	0	0	1	0
LMAAI.0427	0	0	0	0	0	0	0	1	0	0
LMAAI.0428	0	0	0	0	0	0	0	1	0	0
LMAAI.0429	0	0	0	0	0	0	0	0	1	0
LMAAI.0430	0	0	0	0	0	0	0	0	1	0
LMAAI.0431	0	0	0	0	0	0	0	0	1	0
LMAAI.0432	0	0	0	0	0	0	2	0	0	0
LMAAI.0433	0	0	1	0	0	0	0	1	0	0
LMAAI.0438	0	0	0	0	0	0	0	0	0	1
LMAAI.0440	0	0	1	0	0	0	0	0	0	0
LMAAI.0442	0	0	1	0	0	0	0	0	0	0
LMAAI.0451	0	0	0	0	0	0	0	0	1	0
LMAAI.0454	0	0	3	0	0	0	0	0	0	0
LMAAI.0455	0	0	3	0	0	0	0	0	0	0
LMAAI.0458	0	0	0	0	0	0	1	0	0	0
LMAAI.0459	0	0	1	0	0	0	0	0	0	0
LMAAI.0460	0	0	0	0	1	0	0	0	0	0
LMAAI.0461	0	0	0	0	1	0	0	0	0	0
LMAAI.0463	0	0	0	1	0	0	0	0	0	0
LMAAI.0464	0	0	1	0	0	0	0	0	0	0
LMAAI.0465	0	0	7	0	0	0	0	0	0	0
LMAAI.0466	0	0	1	0	0	0	0	0	0	0
LMAAI.0467	0	0	3	0	1	0	0	0	0	0
LMAAI.0468	0	0	1	0	0	0	0	0	0	0
LMAAI.0469	0	0	1	0	0	0	0	0	0	0
LMAAI.0472	0	0	2	0	0	0	0	0	0	0
LMAAI.0474	0	0	0	1	0	0	0	0	0	0
LMAAI.0477	0	0	0	0	0	1	0	0	0	0
LMAAI.0482	0	0	1	1	0	0	0	0	0	0
LMAAI.0483	0	0	4	0	0	0	0	0	0	0
LMAAI.0486	0	0	1	0	0	0	0	0	0	0
LMAAI.0487	0	0	1	0	0	0	0	0	0	0
LMAAI.0488	0	0	0	1	1	0	0	0	0	0
LMAAI.0492	0	0	0	0	0	0	0	0	1	0
LMAAI.0493	0	0	0	0	0	0	0	0	1	0
LMAAI.0496	0	0	1	0	0	0	0	0	0	0

PATTERN	HUMAN		RETAIL				ON-FARM*			
	Endemic cases ON site	Endemic cases BC site	Pork chops	Chicken breasts	Ground beef	Bagged leafy greens	Swine	Broiler chickens	Beef cattle	Dairy cattle
LMAAI.0497	0	0	0	0	0	0	0	0	1	0
LMAAI.0498	0	0	2	0	0	0	0	0	0	0
LMAAI.0500	0	0	0	0	0	0	0	0	0	1
LMAAI.0501	0	0	0	0	0	0	0	0	1	0
LMAAI.0505	0	0	1	0	0	0	0	0	0	0
LMAAI.0509	0	0	1	0	0	0	0	0	0	0
LMAAI.0511	0	0	0	0	1	0	0	0	0	0
LMAAI.0512	0	0	0	0	1	0	0	0	0	0
LMAAI.0513	0	0	1	0	0	0	0	0	0	0
LMAAI.0525	0	0	1	0	0	0	0	0	0	0
LMAAI.0528	0	0	2	0	0	0	0	0	0	0
LMAAI.0531	0	0	2	0	0	0	0	0	0	0
LMAAI.0534	0	0	0	1	0	0	0	0	0	0
LMAAI.0565	0	0	1	3	15	0	0	0	0	0
LMAAI.0584	0	0	3	0	0	0	0	0	0	0
LMAAI.0608	0	0	0	1	0	0	0	0	0	0
LMAAI.0609	0	0	0	1	0	0	0	0	0	0
LMAAI.0611	0	0	0	0	1	0	0	0	0	0
LMAAI.0650	0	0	1	0	0	0	0	0	0	0
LMAAI.0654	0	0	0	0	1	0	0	0	0	0
LMAAI.0671	0	0	1	0	0	0	0	0	0	0
LMAAI.0751	0	0	1	0	0	0	0	0	0	0
LMAAI.0851	0	0	1	0	0	0	0	0	0	0
LMAAI.0852	0	0	0	1	0	0	0	0	0	0
LMAAI.0855	0	0	0	0	1	0	0	0	0	0
LMAAI.0864	0	0	1	0	0	0	0	0	0	0
LMAAI.0880	0	0	0	0	1	0	0	0	0	0
LMAAI.0881	0	0	0	0	1	0	0	0	0	0
LMAAI.0890	0	0	0	0	1	0	0	0	0	0
LMAAI.0922	0	0	0	0	0	1	0	0	0	0
LMAAI.0982	0	0	1	0	0	0	0	0	0	0
LMAAI.0983	0	0	1	0	0	0	0	0	0	0
LMAAI.0984	0	0	1	0	0	0	0	0	0	0
LMAAI.0985	0	0	1	0	0	0	0	0	0	0
LMAAI.0986	0	0	0	0	2	0	0	0	0	0
LMAAI.0987	0	0	1	0	0	0	0	0	0	0
No designation	0	0	3	0	0	0	0	1	6	3
Grand Total	**5**	**0**	**191**	**73**	**149**	**12**	**4**	**8**	**74**	**15**

APPENDIX E — ABBREVIATIONS AND REFERENCES

Abbreviations

BC British Columbia

CFIA Canadian Food Inspection Agency

LFZ Laboratory for Foodborne Zoonoses

MPN Most probable number of organisms

NA Not applicable

ND Not done

ON Ontario

PCR Polymerase chain reaction

PFGE Pulsed-field gel electrophoresis

PT Phage type

VTEC Verotoxigenic *Escherichia coli*

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